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The Welding Engineer

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Founded by L. B. Mackenzie, 1916

FEBRUARY, 1930 VOL. 15, NO. 2

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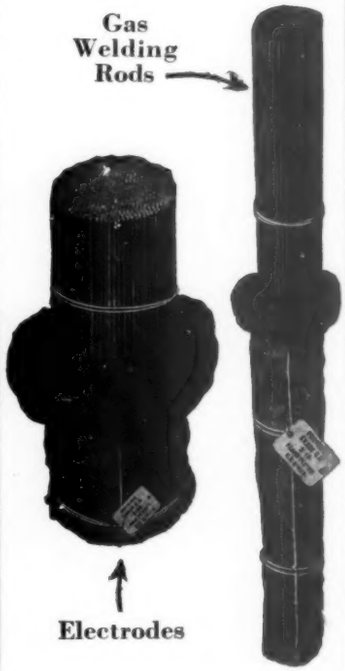

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Founded by L. B. Mackenzie, 1916

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Keep Posted on Good Things

IF ONE were to turn back and look over the equipment and materials offered to the welding industry a year ago and casually read the announcements of the most up-to-date welding products on the market at that time, it would not be difficult to get the impression that the manufacturers in this industry had perfected their products to the highest degree possible. A study of the developments, the equipment and materials during the intervening twelve months would certainly convince the reader that the highest point had by no means been reached a year ago. In fact, there is scarcely anything used in welding which has not been strikingly improved during the past twelve months. While these improvements do not operate to render obsolete all the equipment and materials previously used, they do in a good many cases offer advantages which have justified users of welding in making changes, at the same time representing very attractive offerings to purchasers of new materials. Meanwhile, there have been continuous programs of experimenting in all industries where welding is used extensively, and experiments have repeatedly shown the desirability of careful selection of equipment and materials whenever there is a question of reducing weld failures or obtaining the highest possible operating efficiency. Improvements in equipment and materials are still possible, and the coming twelve months are sure to put on record a number of new products which will simplify the problem of the welding executive. It would pay this man to keep abreast of the progress made in the development of welding products in the future and know what is being done and what is being offered so that he can use the new ideas of the manufacturer to advantage.

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The Welding Engineer does not publish in its news or advertising columns any matter that deals with or refers to either personal or legal controversies.

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Buyers' Index

Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

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Kansas City Oxygen Gas Co.
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Reid-Avery Co.
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Westinghouse Elec. & Mfg. Co.

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Ideal Face Shield Co.
Olympic Glove Co.

ASBESTOS INSULATED WIRE AND CABLE
Central Steel & Wire Co.

BENCHES, WELDING
Standard Pressed Steel Co.

BLOW PIPES
See "Torches"

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N. A. Strand & Co.

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See "Electric Resistance Welders"

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Quasi-Arc, Inc.
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Koro Corporation
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Northwestern Mfg. Co.
Owen Electric Mfg. Co.
Stoody Co.
Waters Welders, Inc.
Westinghouse Elec. & Mfg. Co.
Williams & Co.
Wilson Welder & Metals Co.

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Fusion Welding Corporation
General Electric Co.
Hobart Bros.
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Ideal Face Shield Co.
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Northwestern Mfg. Co.
Owen Electric Mfg. Co.
Quasi-Arc, Incorporated
Stoody Company
Joseph T. Ryerson & Sons, Inc.
Sellstrom Mfg. Co.
Thomson-Gibb Welding Co.
Westinghouse Elec. & Mfg. Co.
Waters Welders, Inc.
Williams & Co.
Wilson Welder & Metals Co.
Wilson Products, Inc.

FIREPROOF PLASTIC MATERIAL
Air Reduction Sales Co.
National Carbon Co.

FLANGES, WELDING
Bonney Forge & Tool Works

FLUE WELDERS (Electric)
General Electric Co.
Joseph T. Ryerson & Sons, Inc.

FLUXES
Air Reduction Sales Co.
Anti-Borax Compound Co.
International Oxygen Co.
Kansas City Oxygen Gas Co.
Lotan Research Corp.
Metal & Thermit Corp.
Central Steel & Wire Co.
Modern Engineering Co.
Oxweld Acetylene Co.

EVERYBODY'S BUSINESS

BY FLOYD W. PARSONS

HOW simple success would be if only we could see ahead clearly. The coming of the railroad, the automobile and the radio brought tremendous changes in life and industry generally. What are the factors today that will remold our habits and practices, carrying us on into still another new era? Will travel by air create new commercial centers and transform what are practically inaccessible lands into valuable holdings?

Unfinished Business

What will be the outcome of the electrification of farming, the consolidation of already large corporations into huge combines, the stabilization of gold, the manufacture of artificial weather on a large scale, the banishment of unnecessary noise, the abolition of slums, and greater scientific effort in the preservation of health?

Those who can anticipate trends have a great advantage. Think of the difference in the opportunity of people entering the electrical industry 20 years ago and those who cast their lot with coal mining. Think how much greater have been the rewards to investors who put their money into automobile manufacture a decade ago than to the ones who put their savings into textiles, fertilizers or boots and shoes.

Underwood & Underwood Studios

FLOYD W. PARSONS is the author of the "Everybody's Business" pages which ran in The Saturday Evening Post for nearly four years. He is now editorial director of several business periodicals, and his writings appear regularly in some of the popular magazines. Probably no other writer of business and popular science stories reaches as large an audience. His contacts with America's leaders of industry are unexcelled. His articles are not only brimful of inspiration, but they contain workable suggestions designed to save time and effort for executives and others in industry.

So the exercise of sound judgment in determining future developments is a highly profitable form of effort. It means a multiplication of opportunities for the fellow who can discern what is needed and then decide if this need will be supplied.

There is much evidence at hand to show that the possibilities for notable achievement have increased rather than diminished. The road to wealth and fame is wider than ever. Hundreds of things are yet to be invented.

Where is the motor engine that does not require decarbonizing; the photographic negative that can be developed in the daylight; a simple device to prevent glass stoppers from coming out of bottles when traveling; an electrically driven bicycle; an indicator to denote when the domestic iron is sufficiently hot to use without scorching the article to be ironed; and a mail box that will receive letter packets singly, record their weight, indicate the amount of money to be inserted, and then, after the coins have been dropped, date-stamp and frank the letter, ready for the post office collector?

All sorts of accessories have been created for use on automobiles, but still there is need for a motor-car windscreen that will remain clear and give a large field of vision without the use of a mechanical wiper. We need an unpuncturable pneumatic tire, and a cheap apparatus for eliminating or absorbing the exhaust fumes that the modern automobile gives off.

Inventive minds must give us a chemical process for making fireproof paper to be used for bank notes and other important documents. We must have a bottle for holding poison which can be easily distinguished; a pencil that marks as black as ink; a rubberized, or other durable fabric for the heels, toes and soles of socks and stockings; a fountain pen to write with inks of different colors, as required; a lighting appliance capable of penetrating fog; a lawn mower that is silent; a magazine hammer that will supply a nail every time the hammer head is struck; and some kind of solvent to wash away all trace of milk from pipes and all sorts of dairy utensils.

Where is there a lifebuoy of pocket size which could be instantly inflated by compressed or liquefied gas by merely pressing a trigger? Where can one find a durable transparent medium that will transmit ultra-violet rays and yet cost very little more than ordinary window-glass?

Certainly we may expect that science may provide us with better methods for cleaning windows, for clearing leaves, paper and other rubbish from gardens and parks, and for eliminating street noises and vibrations from rooms overlooking avenues that carry heavy motor traffic.

The foregoing suggestions are sufficiently concrete to stimulate imagination respecting the practices we will follow in the years ahead.

Anyone walking along city streets will discover endless opportunities for profitable achievement. He will note immediately the need for better name plates on streets, so that these signs can be read easily day or night by motorists and pedestrians. Passing the first firehouse, he will wonder why someone has not discovered a variety of gas that could be used effectively to extinguish fire, thus reducing the damage to goods, and yet which could be pumped like water.

A cloud of dust in the street should carry our thoughts on ahead to the time when there will be contrivances to attract all the particles floating in air in much the same way as a magnet attracts steel filings. A flood of noise should remind us of the need for converting sound into energy. The ringing of a telephone bell should disclose the necessity for perfecting a device to record telephone messages automatically when the person rung up is out. The banging of the wheels of a street car should develop in our minds the picture of an early day when all railways will be noiseless.

Tomorrow we will have cameras that will take photographs in the dark; ink that will dry at once, making it unnecessary to use blotting paper; electric lights that will provide us with cold illumination, doing away with the present loss of 90 per cent of the energy value of the fuel employed to produce the illumination; and radio devices that will transmit and receive visual records almost as readily as we now handle sound impressions.

We feel today that we have made great progress in providing ourselves with a maximum of comfort. But the truth is we are constantly putting up with annoyances or wasting effort needlessly. Practically all of our vehicles pitch and jar and toss us about in a most aggravating manner. We read and write with great difficulty on most of our railroad trains. We endure fearful odors and the stale smell of tobacco in smoke-permeated rooms. We utilize effectively only a fraction of the heat units consumed in warming our homes. We live in an indoor atmosphere in the winter time that is more dry than the air of Sahara Desert. Each of these things is of utmost importance, and it is reasonable to suppose that all of them will soon be remedied by science and invention.

So in view of the speed with which changes now take place in our social and business life, one must look ahead and try to measure the effects on current practices of probable developments. Take a little thing no more important than the invention of the electric flatiron. Who would have believed that in a few years the people of the United States would be using nearly 15,000,000 of these simple appliances? How astonishing

(*Continued on page* 54)

VICTOR

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VICTOR
TRADE MARK

—"on any diameter pipe - - - in bell-holes - - - wherever welding is done VICTOR torches and Safety Regulators are welcome.

It is easy to weld and it is easy to cut with
VICTOR EQUIPMENT

VICTOR WELDING EQUIPMENT COMPANY

844 Folsom Street San Francisco

EDITORIAL

Now Is the Time to Make Welding Repairs

SOME of the most successful manufacturing firms take advantage of times when production is low to install more-efficient equipment and adopt new processes. Such times are also opportune for making repairs.

Because of a lower demand for their products, which is generally thought to be only a temporary condition, certain businesses today have in their plants machinery that is idle a large part or all of the time. During this lull in business, these machines should be inspected carefully and any needed repairs made. Large factories and mills should keep their welding machines and their welding and cutting torches busy in those times that are characterized as a "buyers' market". Broken castings can be repaired, hard-surfaced tools can be refaced, steam mains can be laid, and branches welded into place in old pipe mains, standard products can be redesigned for economy in manufacture and new products devised, needed jigs and fixtures for production of the new products can be fabricated. In all these things the welder's art plays a most important role.

The job welding shop also can take advantage of a situation of this kind. The proprietors of the best known welding shops in the Chicago area state that the making of welding repairs is keeping them busier at this time than they have ever been in the past. It is significant, however, that those welding shops that are getting the bulk of this repair business are widely known for the high quality of their work. One such shop of high reputation was recently called on to make an unusual repair job on a heavy machine in a city about four hundred miles distant. Slack times plus reputation equals profits, is the formula they are working on.

Who Goes to the Welding School?

THE current issue of the official publication of the Denver schools carries a feature article to show the benefits derived by students of the Public Opportunity School. The demand for welding courses is commented on as follows:

"Classes in welding reveal similar stories. Thirty men who had no previous trade were placed as welders last year. Forty already recorded as welders received increases in wages as a result of advanced instruction. One boy, driven from job to job, finally took the course in welding and became, eventually, the foreman in one of the large iron works of Denver. A laborer who attended the welding shop for two years and who is now employed at an aviation field, showed such skill that he received a letter of commendation from a federal inspector."

An analysis of the occupations of 342 students attending the evening classes from September 3, 1929, to January 2, 1930, shows registrations from a total of 57 occupations, the principal ones being general mechanics, auto mechanics, welders, steam fitters, maintenance men, machinists, blacksmiths, welders' helpers, machinists' helpers, pipe fitters, railway mechanics, millwrights, boiler makers, sheet metal workers and structural iron workers. Most of the men attending the evening classes were between 19 and 33 years of age. Eighty-three men attending the day classes in the same period represented 27 different occupations. The Denver school has a wide reputation for the excellence of its program of instruction, both as to the amount of instruction given and the method of teaching the subject. It is interesting to note what a wide range of industries can be served when the instruction in the fundamentals of the process is so thoroughly carried out.

More Shareholders

SINCE the stock-market decline last fall, there has been a marked increase in the number of investors in large corporation stocks. One of America's largest corporations has increased its number of shareholders from 450,000 to 470,000; another one, with a high-priced stock, has added over 6,000 new investors. A large automobile corporation recently reported 198,000 stockholders compared with 117,000 at the time of the "crash". The number of owners of stock in a company manufacturing a high-priced car has increased from 11,000 to 26,000. A ten-cent-store concern has nearly doubled its number of stockholders. A large oil company has added 14,000 new stockholders, and one of the large railroad systems has gained nearly 15,000. Some banks have been reporting comparable increases.

It might be concluded that a large thrifty section of the American public refused to invest during the period of inflation, but now are taking advantage of the opportunity to buy at low prices those stocks that are proved and tested dividend payers. Or it may be that this condition merely indicates a trend among small investors to shift their stock holdings from many of the smaller concerns to the large, well-known companies and corporations.

Whatever the explanation might be, this significant trend should be watched carefully as it probably contains a lesson of great import to business generally as well as to the investor.

How to Get Trustworthy Welds

THE most interesting feature of the proposed revisions of the code covering the construction of unfired pressure vessels is the limitation placed upon those who would use welding in the construction of larger vessels than have previously been welded under the code. It is made very clear that a more extended use of welding in this type of work is permitted only in such cases where the operations are done in accordance with a clearly outlined procedure control. The revisions therefore seem to take the responsibility for good welding away from the welder and place it with the management, where it properly belongs It indicates that systematic and intelligent supervision over welding operations is an acceptable guarantee that the welded article will live up to the expectations of both the fabricator and the user. It has taken a great deal of time and effort on the part of those interested in the success of welding to get these fundamental principles of good welding recognized and accepted. Now that it has been accomplished, the door has been opened to new fields of accomplishment in the application of welding, and it has been done in such a way as to establish a sound and logical foundation for further progress.

Industrial Migration to Be Charted

IN connection with the biennial census of manufactures for 1929 data will be obtained for the first time on migration trends in industry. The schedule will inquire whether the manufacturing establishment reporting was newly established since January 1, 1928, or, if previously established, whether it was before that date, engaged in a different line of business, or was located elsewhere. If the information called for is furnished by the manufacturers, it will be possible to show the interstate migration of industry through these data on changes in name, location, ownership, or general nature of the business. The promptness with which the returns can be published will depend largely upon the cooperation of manufacturers in returning, without delay complete and correct data.

VICTOR TORCHES

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Who Goes to the Welding School?

THE current issue of the official publication of the Denver schools carries a feature article to show the benefits derived by students of the Public Opportunity School. The demand for welding courses is commented on as follows:

"Classes in welding reveal similar stories. Thirty men who had no previous trade were placed as welders last year. Forty already recorded as welders received increases in wages as a result of advanced instruction. One boy, driven from job to job, finally took the course in welding and became, eventually, the foreman in one of the large iron works of Denver. A laborer who attended the welding shop for two years and who is now employed at an aviation field, showed such skill that he received a letter of commendation from a federal inspector."

An analysis of the occupations of 342 students attending the evening classes from September 3, 1929, to January 2, 1930, shows registrations from a total of 57 occupations, the principal ones being general mechanics, auto mechanics, welders, steam fitters, maintenance men, machinists, blacksmiths, welders' helpers, machinists' helpers, pipe fitters, railway mechanics, millwrights, boiler makers, sheet metal workers and structural iron workers. Most of the men attending the evening classes were between 19 and 33 years of age. Eighty-three men attending the day classes in the same period represented 27 different occupations. The Denver school has a wide reputation for the excellence of its program of instruction, both as to the amount of instruction given and the method of teaching the subject. It is interesting to note what a wide range of industries can be served when the instruction in the fundamentals of the process is so thoroughly carried out.

More Shareholders

SINCE the stock-market decline last fall, there has been a marked increase in the number of investors in large corporation stocks. One of America's largest corporations has increased its number of shareholders from 450,000 to 470,000; another one, with a high-priced stock, has added over 6,000 new investors. A large automobile corporation recently reported 198,000 stockholders compared with 117,000 at the time of the "crash". The number of owners of stock in a company manufacturing a high-priced car has increased from 11,000 to 26,000. A ten-cent-store concern has nearly doubled its number of stockholders. A large oil company has added 14,000 new stockholders, and one of the large railroad systems has gained nearly 15,000. Some banks have been reporting comparable increases.

It might be concluded that a large thrifty section of the American public refused to invest during the period of inflation, but now are taking advantage of the opportunity to buy at low prices those stocks that are proved and tested dividend payers. Or it may be that this condition merely indicates a trend among small investors to shift their stock holdings from many of the smaller concerns to the large, well-known companies and corporations.

Whatever the explanation might be, this significant trend should be watched carefully as it probably contains a lesson of great import to business generally as well as to the investor.

How to Get Trustworthy Welds

THE most interesting feature of the proposed revisions of the code covering the construction of unfired pressure vessels is the limitation placed upon those who would use welding in the construction of larger vessels than have previously been welded under the code. It is made very clear that a more extended use of welding in this type of work is permitted only in such cases where the operations are done in accordance with a clearly outlined procedure control. The revisions therefore seem to take the responsibility for good welding away from the welder and place it with the management, where it properly belongs. It indicates that systematic and intelligent supervision over welding operations is an acceptable guarantee that the welded article will live up to the expectations of both the fabricator and the user. It has taken a great deal of time and effort on the part of those interested in the success of welding to get these fundamental principles of good welding recognized and accepted. Now that it has been accomplished, the door has been opened to new fields of accomplishment in the application of welding, and it has been done in such a way as to establish a sound and logical foundation for further progress.

Industrial Migration to Be Charted

IN connection with the biennial census of manufactures for 1929 data will be obtained for the first time on migration trends in industry. The schedule will inquire whether the manufacturing establishment reporting was newly established since January 1, 1928, or, if previously established, whether it was before that date, engaged in a different line of business, or was located elsewhere. If the information called for is furnished by the manufacturers, it will be possible to show the interstate migration of industry through these data on changes in name, location, ownership, or general nature of the business. The promptness with which the returns can be published will depend largely upon the cooperation of manufacturers in returning, without delay complete and correct data.

Roebling Welding Wire

Progressive shop superintendents realize the economy in the use of the various welding processes to replace broken machine parts, and thus reduce annoying and expensive "shut downs."

The welding qualities of Roebling Welding Wire are first—ease of welding; second—a deposited metal that is strong, tough and durable; and third—absolute uniformity.

If you are not using Roebling Welding Wire, it amply merits your consideration.

John A. Roebling's Sons Co.
Trenton, N. J.

Magnetic Testing of Welds

Description of a Method of Obtaining Images of Weld Structures by Means of Filings in a Magnetic Field, and Interpretations of the Results

THE principle of magnetographic examination of welds, discovered by M. Roux, head of the Laboratory of La Soudure Autogene Francaise, and described by Mr. Guillet of the Academy of Sciences on October 24, 1927, is based upon the following general law: A deformable magnetic circuit tends to take the form in which its reluctance—that is to say, its resistance to the passage of flux—is the minimum For example, a bar of iron able to turn between the poles of an electromagnet places itself in such a way that the air gaps are smallest. The reluctance of the arc being superior

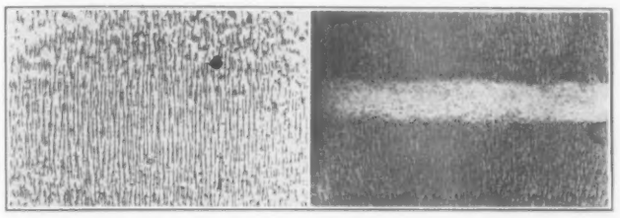


Fig. 1. (Ieft)—On a Magnetized Steel Plate, Not Welded, the Filings Distribute Themselves Uniformly. Fig. 2. (Right)—The Magnetic Reluctance of This Welded Seam Is Greater Than That of the Plate; Hence the Filings Arrange Themselves Over the Plate, Leaving the Weld Bare.

to that of the metal, the axis of the bar tends to direct itself along the lines of the poles.

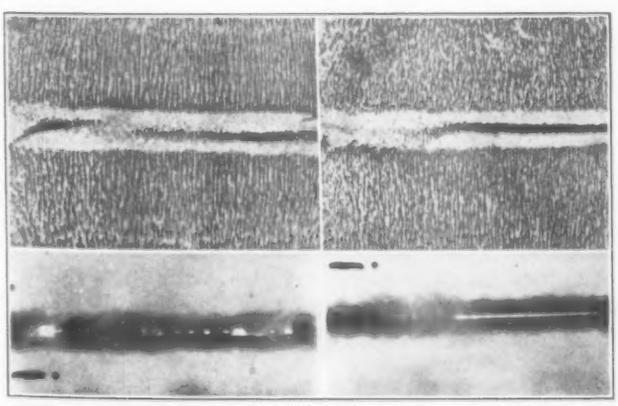
Mobile iron filings in a magnetic circuit mass themselves at the points offering the greatest resistance to the passage of the flux, so as to diminish the reluctance at these points—that is, the filings accumulate at the points of minimum section, or at the air gaps, or those parts of the circuit presenting a deficiency of magnetic permeability.

Weld Structure Revealed by Arrangement of Filings

Starting from this general principle, one is able to explain the different appearances presented by the images of weld structures, which are usually obtained by scattering filings upon the surfaces of welded pieces placed in the magnetic field produced by an electromagnet.

In the case of a steel plate, not welded, the reluctance of the circuit is uniform and the filings distribute themselves uniformly in outlining the lines of force of the flux, which pass from one pole of the electromagnet to the other (Fig. 1).

In the case of a welded steel-plate joint, if the reluctance



Figs. 3 and 4. Magnetographs of Two Welds, With Corresponding Radiographs Below. The Weld on the Left (Fig. 3) Perhaps Contains Slag or Blisters Which Cause the Filings to Accumulate on the Weld in No Particular Order. The Weld on the Right (Fig. 4) Shows Lack of Penetration, and the Filings Form a Line Over the Open Seam. Notice That Where the Filings Accumulate, the Corresponding Radiograph Shows Light Spots and Lines; and Where the Weld Is Bare of Filings, the Radiograph Appears Dark.

of the weld is superior to that of the plate metal, the filings mass themselves around and on the weld. Where the reluctance of the weld is inferior to that of the plate, the filings distribute themselves uniformly over the plate and do not accumulate on the weld, as Fig. 2 shows. If the reluctance of the weld is not constant, by reason of the heterogeneity of the metal caused by slag, blisters, etc., the filings accumulate by placement without any law, by breaking the continuity of the lines of force visible in the homogeneous part of the plate (Fig. 3).

In another case to be considered, the reluctance of the weld presents a discontinuity following a geometric line. Here the filings arrange themselves so as to trace these geometric lines. For example, when there is a lack of penetration, the reluctance of the layer of air between the parts not welded is considerable (Fig. 4).

In the case of steel plate not welded in the shop, there is superposed onto the preceding phenomena the effect of the variations of reluctance due to the differences in thickness

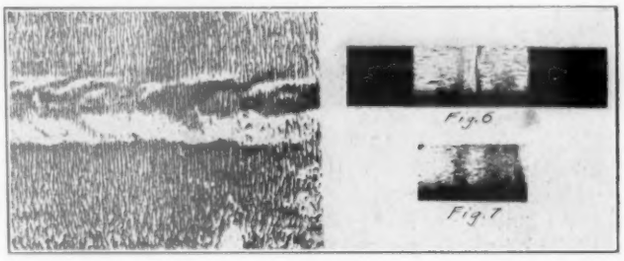


Fig. 5. (Left)—The Surface Waves of the Deposited Metal Causes Variations in the Magnetic Reluctance of the Weld, and Hence Are Shown Clearly in the Magnetograph. Fig. 6. Lack of Penetration in This Tube Joint Is Indicated by the Line of Filings Over the Seam. Fig. 7. The Filings Distribute Themselves More Uniformly When the Joint Is Properly Welded.

arising from the superficial waves of the weld, as is shown in Fig. 5.

Thus it is possible, with some training and judgment, to interpret the magnetic images, or magnetographs, obtained with the filings for the purpose of detecting the qualities and the defects of welds.

Equipment for Producing a Magnetic Field

The magnetic field is obtained by the passage of a direct current through an electromagnet formed of two identical coils wound conveniently on the two arms of an iron core, forming a U. The section of the magnetic circuit being 40 and 70 millimeters and the distance between the poles 90 millimeters.

The poles of the magnet are applied against one of the faces of the test piece in such a manner that they are symmetrical with reference to the weld. After establishment of the magnetic field, the filings are spread upon a sheet of paper applied against one of the faces of the test piece. One is now able to trace the weld structure either on the face that is in contact with the poles or on the opposite face. It is in the latter manner that the magnetographs have been obtained which are reproduced herewith. After the magnetograph is obtained, the filings are fixed upon the sheet of paper by means of a solution of Damar gum in benzine.

The magnetograph in Fig. 6 is representative of an increased reluctance caused by a lack of penetration. A butt-welded tube joint which has been completely welded around may appear by a superficial examination to be perfectly

welded. Yet in the magnetograph there is seen very clearly a ring of filings which corresponds to the geometric line of the interior surfaces of the two tubes, which are in contact without having been fused. Fig. 7 shows a magnetograph of the same tube properly welded.

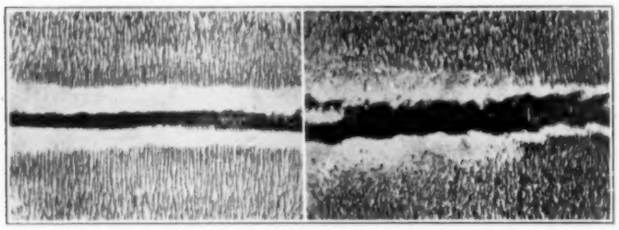


Fig. 8. (Left)—Line of Filings Show Lack of Penetration in This Double-Beveled Joint. Fig. 9. (Right)—Here the Filings Reveal the Break of Continuity Between the Weld Metal and the Parent Metal, Caused by Adhesion of the Weld.

Lack of penetration in a double-bevel joint can be shown by butt welding the edges of two pieces of sheet iron, first on one side and then on the other. The gap thus left results in a considerable increase of reluctance due to the feeble permeability of the air. In Fig. 8 the filings are seen to have massed themselves over this gap so as to diminish the reluctance of the circuit, thus disclosing a cavity invisible to the eye, which constitutes a grave defect in the interior of the weld.

Adhesion is that condition in a weld which results from flowing the metal into the V without fusing the sides of the latter. The magnetograph shown in Fig. 9 reveals clearly the break of continuity between the flowed metal and the faces of the sheet iron which were not fused.

Practical Tests and Their Interpretations

Several typical industrial applications of the magnetographic method will be described.

A drying cylinder under test at a pressure of 2.5 kilograms had started to leak at certain places in the welds. The

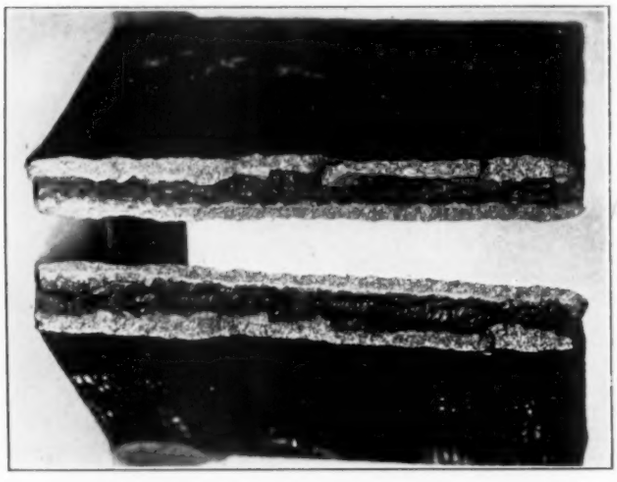


Fig. 10. The Double-Beveled Weld Whose Magnetograph Is Shown in Fig. 8 Is Broken, Revealing Its Structure.

cylinder was 4.5 meters in diameter and 1.4 meters long and was constructed of steel plate of 8 millimeters thickness. The Association of Proprietors of Steam Apparatus, expressing doubt as to the condition of the welds, had decided to check them by a magnetograph examination.

This cylinder is shown in the process of examination in Fig. 11. The white substances with which the welded joint has been coated is a mixture of blanc de Meudon and gum-lac, so as to make appear clearly the magnetograph obtained in scattering filings directly onto the steel plate. The electromagnets are in a vertical position and adhere to the plate by magnetic attraction. The apparatus shown is composed

Fig. 11. Examining a Drying Cylinder by the Magnetographic Method. The Location of a Fault in the Weld Is Indicated by the Chain of Circles.

of two electromagnets energized by direct current at 110 volts.

Fig. 12 shows very clearly a section of holes which had been drilled and then covered with weld metal to close the seam at this point. These holes appear on the magnetograph as a gap several centimeters in length. These holes are outlined on the weld in Fig. 11 to show their position. About 40 centimeters from this defect, at the place where the electromagnets are shown in Fig. 11, there was discovered in the

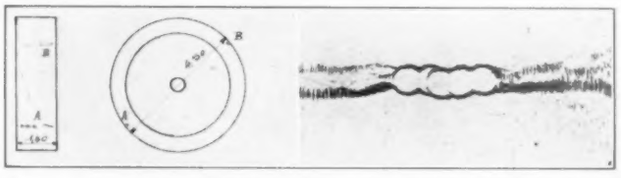


Fig. 12. Diagram at Left Shows Location of Faults in Welds in Cylinder Shell, and the Shape of One of the Faults Is Shown by the Filings in the Magnetograph at the Right.

weld a second flaw, about 10 centimeters in length. In the weld on the opposite side of the cylinder, the holes are outlined clearly, as in the preceding case. Also ,there is clearly shown on this side a second defect 5 millimeters in length.

The magnetographic process permitted examining the welds at the points only where an examination is necessary, without the cylinder having to be dismounted.

The Bakeliting autoclave shown in Fig. 13 is a double enclosure for heating by steam under 7 kilograms pressure. The thickness of the steel plate is 15 millimeters. The welds, coated in white, had been examined vertically with two electromagnets, held against the weld by magnetic attraction. The filings were scattered with a sprayer directly onto the side, and were fixed by a spraying of gum-lac. Fig. 14 shows a line of filings indicating clearly a defect in the homogeneity of the weld. The defects thus revealed were repaired by electric welding after cutting out the bad spots with a torch.

An examination was made of a steam condenser for the purpose of determining if it was possible to detect any cracks in the welds. This condenser carried 17 kilograms pressures and was built of 8.5 millimeter plate.

Before the system of tubes was examined in position, a small welded tube, in which it was known that a small crack actually existed, was removed. The magnetographic examination brought out the crack clearly, whether the magnet was placed against the exterior or convex side or against the interior or concave side. Outside of this very localized crack, the magnetographic examination showed that the weld was sound. Bars were then cut out of the steel plate so as to

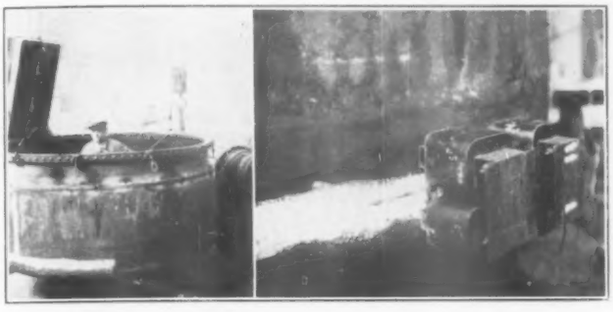


Fig. 13. (Left)—Bakelite Autoclave. (Fig. 14. (Right)—A Cavity in One of the Welds Is Indicated by the Magnetographic Test.

secure a macrograph which would indicate the extent of the crack. This macrograph is also shown in Fig. 15.

After this test a bend 6 meters in length and 290 millimeters in diameter was examined, revealing no defect. The main condenser was similarly examined over the full length of the welds, while warm, and without interrupting the service.

A collar support for the insulator of a transformer tank, made of 12-millimeter plate, was welded with an oxy-acetylene torch, the plate being beveled from both sides. The magnetographic examination, Fig. 16, having revealed a serious defect in spite of the perfect exterior appearance of the weld, it was decided to destroy one of the pieces for examining by the macrographic method and by a fracture of the interior of the welds. The macrographs of the elements removed perpendicularly to the weld show many defects. This was also confirmed by an examination of the fractures, which show clearly that the central interior part was not welded.

The equipment employed for all these examinations is the

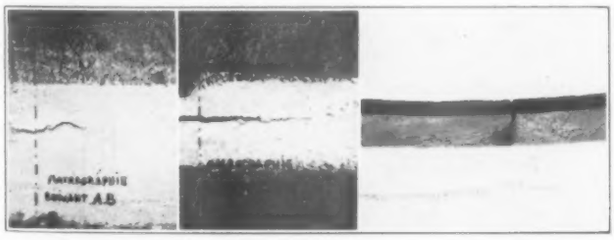


Fig. 15. Test of Condenser-Tube Weld. The Magnetograph on the Left Was Obtained on the Exterior Surface and That Shown in the Center Was Obtained on the Interior Surface, Both Showing the Same Localized Crack. A Coupon Was Then Cut Out, This Revealing the Extent of the Crack, as Shown in the Right-Hand View.

standard equipment of the SAF kit. This equipment can be adapted for plates of average thicknesses not exceeding 10 millimeters. For greater thicknesses requiring a magnetographic examination—for example, on submarine bodies, heavy pipe, and boilers—some work has been done with heavier magnets.

Effect of Magnet Strength on Clearness of Magnetograph

The purpose of the tests made the subject of a report of the Alstrom Society was to determine the excitation and the approximate dimensions of an electromagnet capable of revealing, by examination of the magnetograph obtained with iron filings, a defect covering one-fifth to one-tenth of the thickness of a plate of 25 to 30 millimeters in thickness. By no calculation can the required ampere-turns and dimensions of the magnetic circuit be obtained. In the first test 120 turns of wire was wound on the two arms of the frame of a single-phase transformer. The size of the wire permitted passing for several minutes a current of 1,000 amperes, thus obtaining 120,000 ampere-turns. The dimensions of the electromagnet were as follows: length of the arms, 200 millimeters; distance between the axes of the two arms, 440 millimeters; clearance between the two arms, 240 millimeters; and approximate section of the cores, 300 square centimeters.

Semi-soft steel plate of 25 millimeters thickness was selected of large dimensions in order to more nearly approximate the conditions encountered in practice. The approximate dimensions were 1x0.3 meters.

For the preliminary tests a groove corresponding to a good-sized defect was cut in the steel plate. This test should result in condemning the method if the magnetograph would

Fig. 16. Examining a Welded Steel-Plate Collar, Showing the Magnetograph, Which Is Divided Into Three Zones, and the Macrograph of Each of These Zones.

not detect the groove. At 12,000 ampere-turns the defect appeared clearly.

With the above magnet it was proposed to determine the number of ampere-turns necessary and the defect of minimum dimensions which the method would permit of determination. For this purpose, various sizes and shapes of cuts were made in the plate in order to study the influence of their dimensions, length, width, and depth. Then with the same plates, the same defects, and the same number of ampere-turns, we set about to determine the influence on the magnetic circuit of changes in the dimensions of the electromagnet.

Defects made on the plate included a wide and shallow groove, a narrow and deep groove, and a very deep hole (7 to 8 millimeters in diameter). The grooves were made 22 centimeters from each other for eliminating the reciprocal influence of one groove upon the other, and placed vertically to the large side of the plate, in the direction of the flux.

The wide, shallow groove appears in the magnetograph at 170 amperes and 46 turns, or about 7,820 ampere-turns. Before passing the current, filings were sprinkled over the sheet of paper, then the current was gradually varied until the filings arranged themselves and caused the structural image of the defect to appear.

The magnetograph obtained at 7,820 ampere turns was retained until the current reached 700 amperes, corresponding to 43,500 ampere-turns, without gaining clearness. It did not outline the defect, it simply circumscribed it in a rather regular manner. The image of the defect was clearly separated from the rest of the filings by two white fields. The differences in depth of the various points in the groove were not made evident.

Above 43,000 ampere-turns, it was necessary only to tap lightly on the plate to cause the filings to collect onto the poles.

The next groove was narrow and deep. The magnetograph appeared at 90 amperes and 45 turns, or 4,150 ampere-turns. The width of the magnetograph was notably greater than that of the groove; the defect is apparent though rather poorly defined. When the number of ampere-turns was varied, the magnetic image did not change, but remained a little vague.

The third groove was difficult to bring out because of its small depth. The magnetograph appeared towards 700 amperes with 63 turns, making 43,500 ampere-turns, but it was very poorly defined. It was not characterized by a deeper region of filings, and was not circumscribed by two white fields as were the two preceding images. However, it was useless to vary the number of ampere-turns because the plate had reached the point of magnetic saturation. For a distance of 10 centimeters above the plate, the grains of filings placed in the screen were magnetized. The magnetic circuit was not yet saturated, for the field around the cores remained weak.

The test of the hole gave no results, as we had anticipated. It was impossible to make the image appear whatever be the number of ampere-turns utilized.

In order to study the influence of the distance of the poles, the following test was made:

With the wide, shallow groove on top, we tried to obtain the image below by sprinkling filings by the aid of an atomizer. About 4,800 amperes-turns were required to produce the image. The filings would accumulate only with respect to the defect, which was thus clearly defined, or, better, precipitate on the poles. A heap of filings was obtained over the groove, the rest of the paper remaining white. The obtaining of this magnetograph was facilitated because the magnet was placed on the piece. The grains of filings were then influenced only by the field and not by gravity, as in the previous tests.

A practical application of special interest was the examining of a weld covered by a plate. The wide, shallow groove was covered with a second plate, this being of circular form, 20 centimeters in diameter, and 20 millimeters in thickness. Although the ampere-turns were varied from 5,500 to 50,000, we were not able to obtain an image beyond 50,000 ampere-turns, as the filings placed themselves toward the poles.

The purpose of a third test was to study the influence of the dimensions of the magnetic circuit. To this end an electromagent was wound to the following dimensions: length of the arms, 275 millimeters; clearance between the two arms, 155 millimeters; approximate section of the cores, 110 square centimeters; and number of windings, 45. The tests were carried out on the first and third grooves. No results were obtained, although the current was increased up to 800 amperes, corresponding to 36,000 ampere-turns. The filings did not take the orientation imposed by the direction of the flux. Nevertheless, the magnetic circuit was certainly saturated, for the filings were magnetized all around the magnet save above the plate. The magnetic circuit was saturated therefore before the plate.

Conclusions

1. The dimensions of the large electromagnet are sufficient for the examination of a steel plate of 25 millimeters thickness. But if the defect is less important, as in the third groove under test, the magnetograph is difficult to interpret. The clearness of the image does not depend on the number of ampere-turns. It is impossible to detect a defect the depth of which is less than 10% of the thickness of the plate.

2. If the defect is under a cover joint, it is necessary that the magnet be capable of saturating a thickness equal to the sum of the thicknesses of the plate and cover joint. To examine, for example, a plate of 25 millimeters thickness with a cover joint, requires a magnet for examining 50-millimeter plate.

3. The magnet employed should be far from the saturation point for the maximum number of ampere-turns. The magnet

Fig. 17. Examining a Girth Weld in a Pipe.

we used started clearly to saturate towards 80,000 ampere-turns. It is not necessary that the distance between the poles be very small, except that the attraction of the poles upon the filings be preponderant. The magnet used was not the best in this respect, especially when the magnetograph was made to appear between the two poles.

4. The experience with the small SAF testing electromagnets showed that the thickness of the winding of the coils should not be very great, otherwise the coils give a vertical field that is harmful to a good examination of the weld. The magnet, therefore, should have a considerable distance between the axis, a very thin coil, and in consequence very long cores.

5. By the aid of as much as 43,000 ampere-turns, we have examined a plate of 25 millimeters thickness. We hope, with a magnet of 80,000 ampere-turns, to examine plates of 30 millimeters and perhaps greater thicknesses.

To fix the magnetograph, a sheet of paper is coated with gum-lac by the aid of an atomizer; then, on passing the current, the magnet is dusted with filings. Filings remain attached to the sheet of paper, permitting the taking of blue prints or photographic proofs.

Many more than 7,820 ampere-turns is necessary to obtain adhesion of the filings. In effect, the gum-lac being placed first, the filings are not able to slide on the surface of the paper. In order to obtain the magnetograph, it is then necessary that the filings take their orientation in space and fall upon the sheet of paper at the place where they should remain. Therefore a much more powerful field is required.

Two other procedures have been tried without result. The first consisted in spraying the gum-lac upon the magnetograph. Whatever the number of ampere-turns used, the grains of

filings were driven out by the blast of air caused by the spray.

The second consisted in the production of a magnetograph upon a sheet of ferroprussiate paper and allowing it to receive an impression. This procedure was excellent in the open air, but the necessary light was lacking in the studio.

The material presented here, including the photographs, were obtained through the courtesy of Jean Brillié, of the engineering staff of La Soudure Autogene Francaise, whose assistance is gratefully acknowledged.

OREGON WELDING CONFERENCE

The Second Annual Conference on Welding Methods was held at the school of engineering, Oregon State Agricultural College, at Corvallis, Ore., February 6th, 7th and 8th, and brought together a large group of welders as well as a number of the representatives of manufacturers of welding and cutting equipment. At this year's gathering there was practically double the attendance of the previous year; and so great was the interest manifested in the large program of interesting papers read at the sessions and the displays and demonstrations staged in the laboratories, that this promises to be an annual event.

George B. Cox, director of the engineering shops at the College, introduced H. S. Rogers, dean of the Oregon State School of Engineering, who gave the welcoming address at the noon banquet, in the absence of Dr. William Jasper Kerr, president of the College.

Dean Rogers, in his welcoming address, thanked the representatives of the welding manufacturers and others taking part in the program for their cooperation. He stated that welding held a large place in the scheme of education at the college, and was recognized as a most important adjunct in industrial life of manufacturing and fabrication, and he lauded those instructors at the college who had been successful in making good industrial contacts which would broaden the scope of their work.

"Future Problems of Structural Welding" was the topic of an address by J. R. Griffith, Professor of Structural Engineering, in which he gave his hearers a cross-section of the industry, and expressed the opinion that the engineer of today is still very conservative and yet that the "follow the leader" attitude is to some extent being overcome. He stated that structural engineers should be given more information on welding by means of manuals.

In his paper on "Gas Welding and Cutting of Structural Steel," C. E. Rhein, sales engineer for the Linde Air Products Co., touched on a wide range of subjects of vital importance to the welding industry, urged for better workmanship and modern equipment, compared at some length tests of both welding and riveting on various jobs, and pictured on the screen and described some of the big advances that had been made during the past few years. He also touched on various methods of testing, and urged that all work in the fabrication shop be well inspected.

A. G. Bissell, formerly consulting engineer of the Westinghouse Electric & Manufacturing Co., of East Pittsburgh, and now an independent consulting engineer in the structural field in Seattle, spoke on "Electrical Welding in the Structural Field." He pointed out that the cost of welding at first exceeded riveting, but that it had been reduced materially, and that in welding the savings in design and material should be considered. He emphasized that no major failures have resulted in arc welding, and that most small welded failures originated by using riveted design. He stressed the importance of continuous welds over the intermittent in all classes of work, dwelling for some length on the good results obtained in the building of bridges and also to some extent in the aeroplane field.

Again at the evening session A. G. Bissell replaced Nendall L. Howe, who was unable to be present, and gave his paper on "The Replacement of Gray Iron Castings with Welded Steel," which emphasized the great amount of time that had been saved by employing of welding in the large shops of the country, and predicted that through the satisfactory results obtained its use would shortly be almost universal.

The second speaker of the evening was C. M. Taylor, vice-president of the Lincoln Electric Co., who emphasized the fact that there was still a shortage of trained welding engineers. He predicted that there would be a 100 per cent increase in welded pipe and tanks if specifications calling for welding were inaugurated.

H. R. Patterson acted as chairman of the Logging and Lumbering Section. In opening the first session of the second day of the conference, he gave welding a great boost, declaring that since the advent of portable welding outfits discarded logging equipment was now hard to find in the woods, and that considerable time and money is now saved the logger

"Electric-Arc and Atomic-Hydrogen Welding in the Logging and Lumbering Industry" was outlined in a paper delivered by E. H. Pynn, of the General Electric Co., Seattle, who gave numerous instances of successful atomic-hydrogen welding in the lumber industry, especially in the welding of band and circular saws, but indicated that it was recognized that its use was still limited. Recently a 90-in. circular saw valued at $2,200 was successfully welded in Tacoma. Samples were shown of both aluminum and duralumin welded tubing from the Boeing plant.

Probably one of the most interesting addresses during the entire convention was that of George H. Clark, welding supervisor of the Brooks-Scanlon Lumber Co., of Bend, Ore., who gave a most complete history of practical applications of gas and electric welding for the reclamation of logging equipment. He declared that standard equipment had made logging a specialized business, and that welding had contributed in a great measure to its high plane. It was found that to a growing extent old employees in a number of the logging and lumbering plants are being replaced with real mechanics.

The speaker stated that he had found considerable logging and road equipment on the market inadequately welded, and this he believed was one reason for lack of confidence in welding and for the slowing up of progress of the industry They had also experienced considerable trouble in lumbering and logging plants with electric set works.

Mr. Clark told his attentive listeners that the logging industry was especially hard on machinery and that it should be well welded to hold up. Being worked at high speed and almost continuously during the peak season, only the very best of machinery will stand up. A blackboard talk was used to illustrate comparisons between welded boiler doors and bolted doors, and how best to patch up doors that have been burned out by excessive heat. Welding repairs of this kind are now being successfully done in the woods with portable outfits, the speaker said, and thus considerable expense is being saved in time and equipment. He also stressed the point that welders should not only be able to make successful welds on this work, but should go further and find out the cause of cracks and failures. Boilers were compared to people in that there was a cause of their illness.

In discussing logging road locomotives it was declared that loggers should submit their specifications to the manufacturers, and have the locomotives adapted to their work and this would give better results to both manufacturer and user. More vents were suggested in the boiler, and this was one cause of lap seams being burned out.

After a period of ten years actively associated with both acetylene and arc welding, Mr. Clark stated that he had a preference for them over riveting, and the majority of the work done with this modern method had been very satisfactory. Among the kinds of work done were building up worn surfaces, caterpillar parts, idler wheels, and gasoline and water tanks. The latter, the speaker stated, were built in their own shops, generally during the welder's spare time between big jobs, as they believe in keeping him busy.

It was also stated that a big lumber concern at Bend had turned out some most successful band and circular saw welding jobs, both in putting in teeth in band saws and welding up cracks. Hundreds of dollars have thus been saved for the firm.

They have invariably put in entirely new centers in the saws where cracks appear around the collar line. The speaker advised that better results would be obtained if the whole round center were cut out and a square center put in and in a direction not on the breaking line. After this operation the saw was subjected to 1900 lb. pressure. With this method some $320 was saved in the welding of saws in three days, and all jobs were holding up successfully.

Other addresses that held the attention of the plumbing and steam fitting section, at which L. E. Bringham, supervisor, was chairman, were delivered by E. R. Hodson, Applied Engineering Staff, Portland Oxygen & Hydrogen Co., on "The Oxy-Acetylene Process as Applied to Modern Plumbing and Steam Fitting Industries"; and "The Story of Pipe Cutting and Welding," delivered by E. A. Jordan, manager District "C" (Portland), and representing the Smith Welding Equipment Co., of Minneapolis.

At the afternoon session, S. H. Graf, Professor of Mechanics and Materials, Oregon State School of Engineering, acted as chairman, and C. E. Rhein, sales engineer of the Linde Air Products Co., gave a paper on "Destructive and Non-Destructive Tests of Welds." In his opening remarks, Prof. Graf stated that for the past 21 years he had been testing welds and had noted their continuous improvement, but that experiments were yet being made along this line.

Mr. Rhein interested his hearers in a paper illustrated with screen views. He mentioned the new tests now being used, and said that hydrostatic tests were much in vogue. Stethoscope and X-ray tests were also being used by many, but the latter was still rather expensive. The butt-weld and magnetic tests promise good results Bending tests were fully outlined and pictured with slides on the screen.

"Physical Aspects of Structural Connections, Especially in Designing" was clearly brought to the attention of an increased group of mechanics and students by J. R. Griffith, Professor of Structural Engineering at the University. He gave a new and most interesting manner of testing, placing the ear disc on the welded pipe and using the amplifier, which clearly shows the difference between good and poor welds.

Prof. J. C. Othus, of the University, showed a thorough knowledge of the testing of various steels, stating that the majority did not seem to have a real appreciation of the wonderful properties of strength and elasticity of steel and that experiments had been many and most successful in the college work and would be further carried out. They expect to continue their welding research, he said, though handicapped somewhat by the lack of a structural testing machine.

The Public Utilities Section was the center of an interested audience who heard Charles Newman, welding engineer of the Portland Electric Power Co., outline the successful work accomplished on street railway lines in Portland, and another interesting paper was delivered by F. L. Huggins, of the Portland Oxygen & Hydrogen Co. on "Process of Acetylene in Railroad Work."

"Welding in the Foundry" was the subject ably handled by G. S. Schaller, Professor of Shop Engineering at the University of Washington, Seattle, in which he discussed iron versus carbon, illustrated with drawings. In making repairs to various tools, cost governs, and careful decisions were made as to whether it was cheaper to weld or to replace, but replacements were now at a minimum.

In his address on "Hard Surfacing Welded on Overlays," H. S. Fuller, sales representative of the Stoody Company, Whittier, Calif., declared that hard surfacing is a step in the right direction. However, there are still many who are skeptical and are awaiting further developments, which will be made. Welding rods had been successfully fused by both the arc and acetylene flame, and tungsten had been used extensively in alloys, he said. When successfully done, the hard facing actually becomes a part of the material to which it is applied.

Machinery design practices had been changed which more easily permitted of hard surfacing, especially in oil-well drills. It was at one time considered that hard surfacing was more of a fad than a fact, but of late years this had been overcome. Although this method has been used for the past eight years, there had been very few failures and the prospects are that ultimately it will be in universal use. It has been extensively adapted on lathe tools and steam-shovel teeth and other excavating equipment with good results.

Added to a most complete and educational program was the address of S. W. Dunn, of the Adcox Schools of Portland, on "Welding in The Aeroplane Industry." He was given close attention by a representative number of mechanics and students, many of whom carried away real practical ideas of a growing industry. He declared that aeroplane welding demanded the very finest of mechanics, and that while there were many applicants, but few were able to adapt themselves to the requirements of conscientious aeroplane welders. He expressed a preference for a recruit that would adapt himself to a hard taxmaster, than to have a graduate from the ranks of commercial welders. Also, to do the best work, it was necessary to have the very latest small light welding equipment.

He said that the reason for double strength in aeroplane welds was on account of the landing force of the machine. The designer and welder of an aircraft should work together and study the lifting capacity of their machine; 80 per cent of the load is lifted from the top and but 20 per cent lifted with the under fuselage. In addition to careful design, the selection of materials used in all construction is very important. The plane should be so built that all parts would be readily accessible with a welding torch. It was noted that the majority of failures had occurred at the sides of the welds, rather than cracks in the weld itself.

Plans should carefully be worked out in advance, as wrong procedure had been the cause of many failures. Failures for the most part had not been caused from overheating but from insufficient heat. The speaker declared that the welder should have a physical knowledge of all metals, that the right rods should be selected, and that the shape of the plane while in the course of welding should be carefully watched and the work checked and rechecked. He also stated it was never good practice to bridge over joints.

GAS PRODUCTS ASSOCIATION MEETING

The Mid-Winter Convention of the Gas Products Association was held at the Lake Shore Athletic Club, Chicago, January 20th to 22nd, the closing event being a banquet held in the swimming-pool room, at which water sports were featured. While the convention program centered on discussions of marketing problems confronted by the members, considerable attention was also given the technical aspects of welding.

One of the several interesting papers presented was on "Control of Weld Properties," in which the author, R. W. Holt, research engineer of the Fusion Welding Corp., discussed the various factors influencing the quality of welds, the relative importance of these factors, and how they are interrelated.

A paper on "Welding Copper and Its Alloys by the Oxy-Acetylene Process," presented by I. T. Hook, research engineer of The American Brass Co., indicated that copper can now be obtained that is manufactured to a specification that allows successful welding, and that most copper alloys can be welded readily by the oxy-acetylene process by using the technique that is best for the particular alloy.

R. E. Fritsch, vice-president of Tube-Turns, Inc., in a paper on "Pipe Welding With Stock Fittings," reviewed some of the more important advantages of welded pipe lines with particular attention given to the use of forged steel fittings for making changes in direction.

The history of welding in Russia, together with a description of industrial progress in that country, which indicates that it is a potential field for great lots of welding equipment and supplies, was outlined in a paper written by A. A. Heller and read by W. F. McKay, both of the International Oxygen Co.

Code Revisions for Pressure Vessels

Air Vessels of Greater Sizes and Pressures May Be Welded If Proposed Revisions to A.S.M.E. Code Are Adopted

IN THE January issue of The Welding Engineer there was published a paper on the present attitude of the authorities toward the welding of boilers, pressure vessels and steam lines, which was presented by C. W. Obert of the Union Carbide & Carbon Research Laboratories before the Convention of the International Acetylene Association, which was held in Chicago last November. In this paper it was pointed out that the Boiler Code Committee of the A. S. M. E. was taking steps to revise the unfired pressure vessel code. Since that time the Boiler Code Committee has published a number of suggested revisions on which criticisms and comment have been invited. Such comments should be forwarded to the Secretary of the Boiler Code Committee, 29 West 39th St., New York City. Some time will be allowed for the collection and consideration of discussions of the proposed revisions before they are finally approved.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in lower-case type enclosed in parentheses.

Proposed Revisions

Par. U-23 Revised:

U-23. Pressure vessels shall not be fabricated by means of fusion welding under the rules given in Pars. U-67 to U-79 except:

a. Air vessels, when the diameter does not exceed 20 in., the length does not exceed 3 times the diameter, and the working pressure does not exceed 100 lb. per sq. in.

b. Other vessels, under these rules, in which the circumferential joints only may be welded, when the inside diameter does not exceed 48 in., or 72 in. when at least 75 percent of the load on a flat head is supported by tubes or through stays extending from head to head.

Par. U-68 Revised:

C. WHERE THE VESSELS ARE FABRICATED IN ACCORDANCE WITH THE RECOMMENDED PROCEDURE FOR FUSION WELDING OF PRESSURE VESSELS GIVEN IN THE APPENDIX, THE LIMITING DIAMETER IN PAR. U-23A MAY BE TAKEN AS 60 IN. AND THE LIMITING PRESSURE MAY BE TAKEN AT 200 LB. PER SQ. IN., PROVIDED THE TEMPERATURE DOES NOT EXCEED 250 DEG. FAHR. PAR. U-68 REVISED:

U-68. WHEN WELDED IN ACCORDANCE WITH THE RECOMMENDED PROCEDURE FOR FUSION WELDING OF PRESSURE VESSELS GIVEN IN THE APPENDIX, THE STRENGTHS OF JOINTS MAY BE CALCULATED ON A MAXIMUM UNIT WORKING STRESS (S), AT RIGHT ANGLES TO THE DIRECTION OF THE JOINT, AS FOLLOWS:

FOR BUTT DOUBLE V LONGITUDINAL WELDS.....8000 lb.
FOR BUTT SINGLE V GIRTH OR HEAD WELDS.....6500 lb.
FOR DOUBLE FULL FILLET LAP OR GIRTH WELDS.....7000 lb.
FOR SPOT OR INTERMITTENT GIRTH OR HEAD WELDS.....5600 lb.

UNLESS THE PROCEDURE FOR FUSION WELDED VESSELS GIVEN IN THE APPENDIX IS FOLLOWED IN ALL PARTICULARS (when properly welded by fusion process) THE (strength of a joint may be calculated on a maximum) UNIT WORKING STRESS (S) AT RIGHT ANGLES TO THE DIRECTION OF THE WELD SHALL NOT EXCEED 5600 lb. per sq. in. (see Par. U-20).

Recommended Procedure for Fusion Welding of Pressure Vessels

It is the purpose of this statement to outline such a course of procedure, embracing the essentials of proper fusion welding, as will not only insure sound and safe welded construction for pressure vessels, but will also enable such results to be duplicated at any place and at any time. This procedure outline is general in character and contemplates the use of any of the established methods of fusion welding, either hand or machine, for the construction of pressure vessels. The subject-matter is presented under the following subdivisions:

I. Materials
II. Design.
III. Construction
IV. Qualification of Welders
V. Supervision
VI. Inspection
VII. Testing

I.— Materials

Plate for Shell, Heads, etc. Steel plates for any part of a vessel that are subject to stress produced by internal pressure and are welded, shall be of good weldable firebox or flange quality conforming to the Specifications for Steel Plate of Flange Quality for Forge Welding, as given in Pars. S-264 to S-279, or to the Specifications for Steel Boiler Plate in Pars. S-5 to S-17 of Section II. of the code.

Material for Manholes, Nozzles and Other Connections. Material for manholes, nozzles and other connections with are to be joined to the shell or heads by fusion welding, shall, when forged or rolled, comply with the specifications given for shell plate and heads as to chemical and physical properties, and be of good weldable quality. Steel castings and commercial nozzles may be used only when the material has been proved to be of good weldable quality.

Filler Material. Welding wire, rods, or electrodes must be smooth and free from scale, rust, oil or grease. In the hands of an experienced welder, the filler material shall demonstrate good weldability and shall flow smoothly and evenly without any unusual characteristics.

Electrodes for metal-arc welding of all kinds shall conform to the American Welding Society Specifications E1A or E1B.

Welding rods for gas welding shall conform to the American Welding Society Specifications G1A.

Other welding rods, wire, or electrodes may be used provided they give results equal to or better than those specified in Section IV.

II.— Design

The design of all pressure vessels shall conform to the various requirements of the Code for Unfired Pressure Vessels. In applying the rules of this code, however, care should be taken to proportion and so place the constituent parts of the vessel that due consideration may be given to the requirements of the welded joint. In all cases where plates of unequal thicknesses are butted, it is desirable to reduce the edge of the thicker plate in some manner so that it is approximately the same thickness as the other plate; this is an exceedingly important element in obtaining complete fusion and should be treated as one of the factors contributing to a sound and safe welded joint. Furthermore, in the design of welded vessels care should be taken to so locate the welded joint that the bending stresses that are inevitable in certain shapes of structures will not be brought directly upon the welded joint; as an instance may be cited the case of dished heads on cylindrical vessels, in which the weld should not be applied directly at the knuckle of the head. Corner welds should in general be avoided unless the plates forming the corner are properly supported independently of such welds. Lap joints should be avoided for heavy stresses or for the

joining of thick plates. In general, welds in tenion or shear are much to be preferred over those subjected to other forms of stress. The design of parts of cylindrical vessels other than the shell should be so controlled that satisfactory welded design is assured and that the vessel will have uniform strength throughout; this applies particularly to large outlets and manhole openings.

III.— Construction

Preparation for Welding. The plates or sheets to be joined shall be accurately cut to size and formed. In all cases the forming shall be done by pressure and not by blows, including the edges of the plate.

Bars, jacks, clamps, or other appropriate tools may be used to hold the edges to be welded in line. The edges of butt joints must be so held that they will not be allowed to lap during welding.[1] For plates in excess of ¾-inch thickness the offset must not be more than 10 percent (maximum ¼ inch) for girth seams. Where fillet welds are used, the lapped plates shall fit closely and be kept tight together during welding.

The surfaces of the sheets or plates to be welded must be cleaned thoroughly of all scale and rust for a distance of about ½ inch back from the welding edge. A steel-wire scratch brush may be used for removing light rust or scale, but for heavy scale, slag, and the like, a grinder, chisel, air hammer, or other suitable tool should be used that will clean down to bright metal. When it is necessary to deposit metal over a previously welded surface, any scale or slag therefrom should be removed by a roughing tool, a chisel, an air chipping hammer, or other suitable means to prevent inclusion of impurities in the weld metal. In case there is grease or oil on the welding edges, it should be thoroughly cleaned with gasoline, lye, or the equivalent.

Welding Method. The application of this welding procedure is not limited to any method or process of welding or to any particular materials, but it is essential that the method or process shall be capable of effecting thorough fusion of the weld metal to the edges to be joined. There are no limitations as to the preparation of the edges to be welded except as provided in Par., U. 71 of the code that for the longitudinal joints of cylindrical vessels, double-V-type welds must be applied. It is here pointed out that while Par. U-71 requires for double-V welds penetrating half-way through from each side, a well-made single-V weld which is reinforced at its root is considered to be satisfactory. In cases when fusion at the root is irregular, the root of the weld shall be chipped out before reinforcing.

The dimensions and shape of the edges to be joined shall be such as to allow thorough fusion and complete penetration.

A full and complete penetration of the weld metal through the entire thickness of the plate is essential for safety, considerable precaution must be taken to insure this result. If the welding is stopped for any reason, extra care must be taken, when restarting, to get full penetration to the bottom of the joint and thorough fusion between the weld metal and the plates and to the weld metal previously deposited.

In double-V butt welds the edges to be joined shall be so separated that the weld metal can penetrate to the root of the V.

Before welding the second side of the double-V, all scale and metal which has run through from the weld on the first side must be removed by some suitable method such as by chipping or grinding, and the rust removed from the adjacent surfaces for ½-inch back. Any suitable means such as a round-nosed chisel may be used to remove the metal from the V, and a portable grinder to clean the scale from the plates.

When single-V joints are used, particular care must be taken in lining up and separating the edges to be joined so that complete penetration and fusion at the root of the V will be assured, for in some instances it will be impracticable to eliminate any lack of fusion by reinforcement of the opposite side—for example, on head seams of tanks less than 3 feet in diameter and containing no manhole.

Particular care should be taken in the layout of joints in which fillet welds are used so as to make possible the fusion of the weld metal at the bottom of the fillet. Great care must also be exercised in the deposition of the weld metal so as to secure satisfactory penetration.

Reinforcement and Finish. The reinforcement of welds shall, in accordance with the requirement of Par. U-71 of the code, be built up uniformly from the edge of the plate to the maximum at the center of the weld. Particular attention is called, however, to the importance of the provision in that rule that there shall be no valley or groove along the edge or in the center of the weld, but that the deposit metal must be fused smoothly and uniformly into the plate edge at the top of the V[2]. The finish of the welded joint must be reasonably smooth and free from irregularities, grooves or depressions.

If a cylinder shell shows irregularities after welding, it shall be rerolled to render it truly cylindrical, or the ends may be heated and shaped to come within the following limits:

The edges of the plates at the seams shall not offset from each other at any point in excess of one-quarter of the thickness of the plate except for plates in excess of ¾ inch in thickness, in which the offset must not be more than 10 *percent* (*maximum ⅛ inch*) *for longitudinal seams, or* 25 *percent* (*maximum ¼ inch*) *for girth seams.*

If the thickness of a head to be attached to a cylindrical shell by a butt joint exceeds the shell thickness by more than 25 percent (maximum ¼ inch) the head thickness shall be reduced.

Heads concave to pressure and plate edges at girth seams to be attached by butt joints shall be lined up with the shell as true as possible, dividing up any offsets. If these are more than permitted by the above limitation, corrections shall be made by reforming the shell or head, whichever is out of true, until the errors are within the limits specified. The sheets at head and girth seams shall be kept so spaced that they shall be separated at the point of welding enough to insure thorough penetration of the weld metal.

Heads convex to pressure shall, as prescribed in Par. U-74 of the code, be prepared and applied with a length of flange of not less than 1 inch for shells not over 24 inches in diameter but of not less than 1½ inches for shells over 24 inches in diameter. It is recommended in the code that this length of flange be made not less than 12 percent of the diameter of the shell.

IV—Qualification Test for Welders

The qualification test will consist of welding together in a flat position two plates of the same material and thickness as is to be used in the tank under consideration (see Fig. 1). Should the welder be required to make fillet welds, butt welds over ⅝-inch thick, or welds in other positions than in the flat, he shall qualify in that class of work. If a backing strip be used in practice for single-V butt welds, it may be employed in making the test specimens. After cleaning and straightening the plates and machining the edges to be welded, they shall be clamped down and the edges of the V lined up (see Fig. 2). It is important that the edges of the V shall not lap during welding and thus prevent full penetration. To this end the plates shall be so spaced before starting the weld that, at the point of welding, there shall be a slight distance between the edges of the V.

The test plates shall be cut up as shown in Fig. 1 by the dotted lines and the two outside strips rejected because they

[1]Attention is called to the requirement in Par. U-71 of the Code that stipulates that the sheet on one side of the joint must not be allowed to offset from opposite sheet by more than one-quarter of their minimum thickness.

[2]If the reinforcement is built up so as to form a ridge with a valley or depression at the edge of the weld next to the plate, the result is a notch which causes concentration of stress and reduces the strength of the joint.

may not be truly representative of the weld. This cutting may be done with a gas cutting torch. Pieces 1, 3, and 5 shall be machined as shown in Fig. 3. The reinforcement should be ground or machined off both sides. The last grinding or tool marks should be parallel with the length, and not at right angles to it.

The test specimen shall then be tested in a tensile testing machine to determine the ultimate strength in pounds per square inch.

The ultimate strength determined by tensile test will be the basis for the welder's rating. In order for him to qualify, the tensile-strength results should average at least 45,000 pounds per square inch, with no one test piece giving less than 42,000 pounds. If these results are not reached, the welder may be given a duplicate test. If the welder successfully passes this test, he shall be considered qualified.

The record of a welder's qualification test should contain complete information concerning the material of the plate welded, the filler metal used, the type of welding equipment, any pertinent particulars concerning its operation, and the

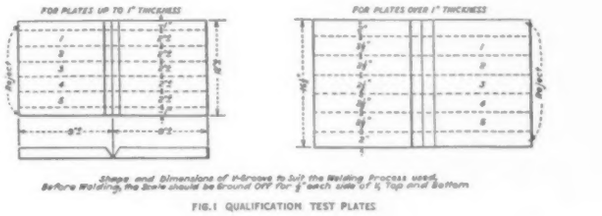

FOR PLATES UP TO 1" THICKNESS
FOR PLATES OVER 1" THICKNESS
Shape and Dimensions of V-Groove to Suit the Welding Process used.
Before Welding, the Scale should be Ground Off for ½" each side of ½ Top and Bottom

FIG. 1 QUALIFICATION TEST PLATES

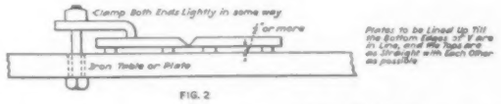

Clamp Both Ends Lightly in some way
Iron Table or Plate
Plates to be Lined Up Till the Bottom Edges of V are in Line, and the Tops are as Straight with Each Other as possible

FIG. 2

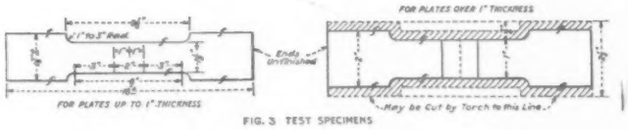


FIG. 3 TEST SPECIMENS

quality of the weld not only as to completeness of fusion with the base metal but also as to completeness of penetration. Any peculiarities of the weld should also be noted such as finish and surface defects, style and amount of reinforcement, and appearance of weld on underside at bottom of V.

V—Supervision and Local Inspection in Shop

The welding supervision constitutes the system of oversight and shop inspection which insures that the provisions for proper Materials (1), proper Design (2), proper Construction (3), and properly Qualified Welders (4), shall co-operate as to give sound and safe welded construction. It is the duty of the management of the welding shop to provide such supervision and local inspection as will make sure that the requirements of the Code for Unfired Pressure Vessels and also those of this Recommended Procedure will be carried out on any welded pressure vessels to be stamped as provided for in the code.

It is preferable, although not essential, that those who are charged with this supervision shall have a practical knowledge of fusion welding, particularly with the process that is employed. The supervisor shall provide and have readily accessible for purposes of record all necessary data concerning the material, designs, qualification of welders, etc. The assent to and signature upon the manufacturer's data report by the manufacturer's representative constitute a guarantee that the vessel conforms to the requirements of the Code for Unfired Pressure Vessels.

Any local inspection that may be provided in the manufacturer's shop must be arranged to function without possible interference with the work of the authorized inspector from the outside and employed under the terms of Section VI. Such local inspection would obviously be operated as a service of the manufacturer to check the employees and make sure that they are carrying out all instructions and the details of this procedure.

VI—Inspection

The manufacturer shall arrange for inspection of the pressure vessels during construction, as provided for in Par. U-65 of the code. The inspector employed for this purpose shall not be in any way connected with the management of the shop performing the welding, but shall be a state or municipal inspector or an inspector regularly employed by an insurance company engaged in boiler or pressure-vessel inspection work.

It shall be the duty of the inspector to check the construction of the vessel to make sure that the provisions of this Recommended Procedure are carried out. He must arrange his inspections covering materials, design, and construction to conform to code requirements, and the qualification of welders to meet the convenience of the supervisor or other representative of the manufacturer, and be prepared to sign the data report furnished by the manufacturer. He must direct particular attention of the manufacturer to the requirements for testing of welded vessels in Par. U-78 of the code.

Inspection of Material. The inspector shall satisfy himself that all material used in the manufacture of a vessel is in accordance with the code requirements, and if he desires he may secure from the manufacturer a written statement to the effect that it is, to the best of his knowledge and belief, in accordance with the code. All parts shall be examined whenever possible before they are assembled as well as after they are applied. Material having injurious defects as referred to or defined in the code shall be rejected.

The inspector shall see that plates are properly stamped before being used. Should the identifying marks be obliterated or plates separated into two or more parts in the process of work, he shall see that such marks are properly transferred under code requirements.

All material shall be gaged or measured to determine whether the thickness meets with the code requirements, due allowance being made for code variations. During the process of manufacturing a vessel, the material shall be inspected for surface defects, cracks, blisters, pit marks, blowholes, or any other defects liable to develop in fabrication, and for excessive hammer marks. If defects are sufficient to materially impair the strength, the vessel shall not be stamped with the code marking. If depressions are found, careful measurement shall be made, and if by reason of the reduced thickness the plate is not weaker than where machined for holes or openings for connections and outlets, it may be accepted, provided that in no case shall a plate be accepted having a depression greater than 15 percent of its thickness and not exceeding 4 inches in its greatest length. Plates that are found laminated shall be rejected.

All cast parts when ready for use shall be carefully examined to determine that the walls are not less than the designed thickness, free from injurious defects, and annealed as required by the code. All lugs, brackets, nozzles, flanges, manhole frames, and other appurtenances shall fit snugly and conform to the curvature of the shell or surface to which they are attached.

After the shell is welded, the inspector shall inspect the welds from the inside and the outside of the shell and record their appearance. Before examining a weld, the outside and inside of the shell shall be struck all along the length of the weld with a hand hammer to break loose the scale. A wire brush shall also be used to clean the surfaces. Double-V welds shall be hammered the same as single-V welds.

In any case low spots in or at the sides of the weld may be filled up as in the case of pinhole repairs. If the low spots are not longer than four times the thickness of the plate, and

if they do not go below the surface of the plate, they need not be repaired.

VII—Testing

After welding has been completed and the vessel has cooled and is ready for testing, it shall be given the hydrostatic pressure test as prescribed in Pars. U-65 and U-78 of the code. The water used for testing shall preferably be of a temperature not less than that of the surrounding atmosphere, or at least not under 70 degrees Fahr.

Care shall be taken in filling the vessel to set it up with one of the outlets on top and leveled so that all of the air therein can escape when it is filled with water. A test gage shall be connected to a suitable outlet on the vessel which shall preferably read to approximately double the maximum hydrostatic pressure. The connection to the gage should be fitted with a cock or valve so as to prevent the shock of hammer testing from being communicated to the delicate gage mechanism.

The pressure shall be slowly raised until it meets with the code requirements for the type of vessel under test, and shall be held there long enough to enable the inspector to examine all visible parts. If the tank is entirely free from leaks under these tests, it shall be accepted by the inspector, who shall certify thereto on the data report form. If leaks occur, they may be repaired in the following ways:

Pinholes, except on longitudinal seams, may be calked, filled with a plug not to exceed ¼ inch, or welded by the metal-arc process without preheating, or they may be melted out and rewelded by any process, providing the metal around the pinhole is preheated to a dull red for a distance of at least 4 inches all around it. Any preheating means may be used, such as a flange fire, gas or oil burner, or a welding torch. The preheating should be done slowly, so the heat will get well back into the plate and expand it thoroughly. After welding, the tank should be reheated in the vicinity of such weld until the heat has equalized in the dull red spot, and then slowly cooled.

Pinholes in longitudinal seams must be repaired only by cutting or melting out the defect and rewelding with the above precautions in regard to preheating and reheating, except that with metallic-arc welding, preheating and reheating are not required. Cracks in welds shall only be repaired by cutting out the weld and rewelding the entire seam.

After repairs have been made, the tank shall again be tested in the regular way, and if it passes the test the inspector shall accept it. If it does not pass the test the inspector can order supplementary repairs, or if in his judgment the tank is not suitable for service he may permanently reject it.

WELDED PIPE LINES CARRY STEAM AND ACETYLENE

The welding of steam and acetylene pipe lines connecting the two plants of Shawinigan Chemicals Limited, Shawinigan Falls, Quebec, is described in a recent issue of *The Welding Review*. The acetylene line which is 24 in. in diameter and carries more acetylene than any other line in the world, closely parallels the welded steam line for more than half a mile. The oxy-acetylene welding process was used. Mild-steel plates were shipped to the job and rolled on the spot, and the longitudinal and girth seams welded. The installation contract was awarded to the Canadian District Steam Co., who carried out the work under severe winter weather conditions. The steam line carries 175 lb. pressure and 100 deg. superheat and is constructed of 8-in. extra-heavy steel pipe. All joints, including bends and expansion loops, are welded. The contour of the district presented many difficulties, but the welding process facilitated running the line over roofs, around buildings, over railroads, across ravines and gullies, and resulted in a leakproof line that will be free from maintenance expense.

FIRST ARC-WELDED MEXICAN PIPE LINE

The first arc-welded pipe line in Mexico, constructed for the transportation of natural gas for the Compania Mexana de Gas, a subsidiary of the United Gas Co., was recently completed. This new line is fabricated of 12-in. pipe and is 165 miles long, running from Aquilares to Roma, Texas, then across the Rio Grande River, via the International bridge, to San Pedro, Mexico, and thence to Monterey, Mexico. It was constructed by Smith Bros., Inc., general contractors of Dallas, Texas, and was started from both the United States and the Mexican sides of the Rio Grande, the two gangs working toward each other.

The difficulties experienced in the construction of the Mexican part of this line were many and varied. It was laid over mountains, through primitive forests, and across rivers, and most of the labor used was inexperienced because of the Mexican law requiring that a majority of the work be done by natives who are residents of the state in which the work is going on. It was necessary to train these inexperienced laborers to do the welding as well as to operate the excavating machinery.

The current for welding was furnished by 90 gas-engine-driven welders, 48 of which were used on that portion of the line in the United States and 42 on the Mexican portion. The welders were moved into position along the line by caterpillar tractors, and fuel for the engines was supplied from a truck. All the welders and electrodes used in the construction of this line were manufactured by The Lincoln Electric Co., of Cleveland, Ohio.

UNCLE SAM WANTS WELDING ENGINEER

Recently the United States Civil Service Commission announced an open competitive examination for the position of senior welding engineer. The duties of this position as listed in the commission's announcement of the examination are as follows:

"To extend the application of welding in the construction of naval vessels; to keep in touch with the latest developments in the industrial field of welding; to have general oversight over the welding processes at navy yards with a view to coordinating and perfecting their methods; to initiate tests and research and to analyze the results of experiments; to prepare specifications for and advise as to the selection and purchase of welding appliances and materials; to criticize design and detailed structural plans of Naval vessels as affecting and as affected by the application of welding; and in general to advise the Bureau of Construction and Repair, Navy Department, on all matters pertaining to the application of welding to ship construction."

The resume of the prerequisites for this position is quoted also in part as follows:

"In addition (to a college or university degree in engineering), the applicant must show that he has had at least six years of extended professional experience in engineering, consistent with the duties of the position, at least three years of which were of a responsible supervisory or administrative character, in which the applicant has been engaged in the direction or performance of important mechanical-engineering work, including research and development in connection with the industrial application of modern methods of welding. Such experience must indicate outstanding professional attainment and proven research and executive ability of a high order, and must show a high degree of progression in duties, responsibilities, etc."

The most significant thing in this announcement is that the entrance salary for this position in Washington is the highest entrance salary paid to any engineer under the United States Civil Service. Those interested in the progress of welding may view with satisfaction the attitude of the United States Government towards this field of engineering. The great strides made by welding in recent years in the whole industrial field have made it a vital and nearly universal method of joining metals in all lines of fabrication and repair. The importance which the Government now attaches to the profession of welding engineering may be regarded as another step forward in the growing general confidence in and enthusiasm for welding.

Hard Facing in the LimestoneIndustry*

Application of Hard-Facing Alloys and Comparative Results of Tests

By E. H. Baker†

THIS paper will be confined to the use of hard-facing alloys on stone-working tools. We of the limestone industry find it much easier to talk about our problems and difficulties than about the successes we have had. We might say, however, we have had some very encouraging results, but much remains to be done before we reach our aim.

Various industries give rather glowing reports about the application of hard-facing alloys. Oil-well drillers tell of going through hard formations with tools that give wonderful service, resisting the abrasive to a high degree. Other industries report using them in various ways to overcome excessive wear. The metal-working industry, we find, is using large quantities of this material in the making of dies, etc., as well as machine tools.

Since we were in need of something of this character, a number of manufacturers of hard-facing alloys were consulted. We gave them a discription of the work, as well as the size and shape of the tool, and the type of machine on which they were to be used, and furnished samples of stone so that they might study our requirements and give us some advice. The result was that we had

Moulding of a Gothic Arch Member on Circular Planer.

a number of alloys with which to make tests. In making these tests we followed instructions very closely and varied them only when attempts were made to improve them. When results were not satisfactory we promptly reported them to the engineers, giving details of methods used, the manner in which the tools failed, and how the tests were conducted, so that they might make suggestions. The suggestions were many and varied.

As to the application with the ferrous alloys, suggestions were made to change the amount of carbon introduced by the acetylene torch. We were asked to try tools with more carbon introduced; and if these were unsatisfactory, to try tools with less carbon

*Paper presented before the Fifth Annual Welding Conference held at Purdue University, Lafayette, Ind., December 11-13, 1929.

†Indiana Limestone Company, Bloomington, Ill.

Courtesy Indiana Limestone Co.

introduced. Heat treatments were suggested by some. Some engineers forwarded other grades of their metals. It was impressive to see that this was an experiment not only with us, but with everyone else, and all were quite interested in the results.

Machining of the Various Grades of Limestone

When a difficulty arises in machining a material, it is necessary to know something of its character. In the study of limestone we find many different grades. The softest grades, known as the "Selects," are very fine of texture. The abrasive contents are very small and present no difficulty in machining. They are used principally where very fine finishes are needed and for statuary and intricate carving.

The intermediate grades are many and varied, and more buildings are fabricated from these grades than from all others combined. They are used for interior finish as well as exterior. Some of these grades contain many foreign substances, some of which show up quite distinctly on close examination. Not all these grades are hard to machine, however, but there are a few that contain enough abrasive as to be a matter of concern.

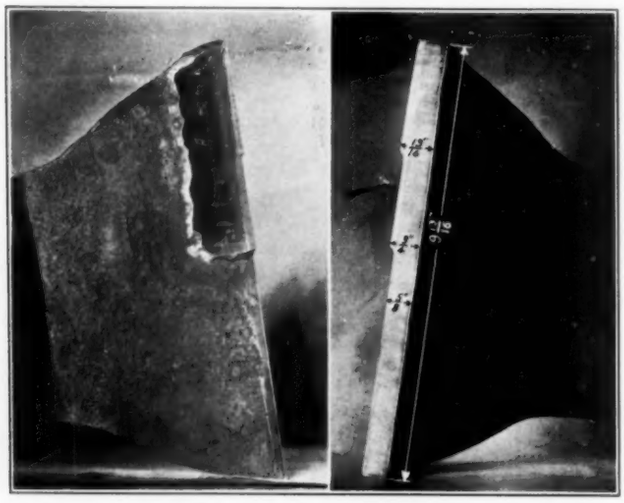
We have the extremely hard grades known to stone men as "Rustics" and "Gothics," which until recent years were considered a waste in the quarry and treated as such. Architects recently have become interested in these grades and in the last few years demands for them have greatly increased. They present our greatest difficulty because of the varied formation. We find large deposits of flinty nature, known to the stone men as "flint," that are extremely hard on tools. This grade has hard and soft spots that, as it is being machined, present a sort of shock or impact to the edge of the tool. Large deposits of silica and ores of various natures and the pyrites, generally appearing as irregular pencil seams called "crow foot," may appear throughout its structure. The content abrasive elements is extremely high. Since these grades of stone have been in demand, carbon steel has become less satisfactory as tools and stone men have begun to look about for something that would give greater production.

When the large blocks are quarried and shipped to the mills, these are placed in gang saws. These saws are made up of a number of steel blades about 4 in. wide by $\frac{3}{16}$ in. thick. These blades are placed in large frames and stretched very taut, and a cutting abrasive is supplied in the form of sand and water. These blocks are sawed into slabs of predetermined thickness. They are then placed on the planers to be formed into various shapes. These planers are very much like those used in the metal-working industries, except for a few minor differences, and are very heavy and rugged. It is on the tools of these planers that we started our experiments with hard-facing alloys.

The tools of these planers differ very markedly from those in use in other industries. They are drawn from 1x6-in. stock, with the cutting bit up to 14 in. in width. They have a forward bend

of approximately 50 deg. This bend varies for different stones and also by the difference of opinion of stone men.

We use an unusual method of grinding. The back of these tools is ground straight with the bit; the front may be straight with the shank or it may be sloped back toward the shank to give it up to 8 deg. positive rake. This is also a matter of opinion of the men who use them. This grinding would seem to present more of a scraping edge than one that would cut and leaves a somewhat delicate edge of the tool where the abrasive of the stone can do the greatest damage. In order to finish the



Planing Tool. At Left, Hard Facing Application Partly Completed. At Right, Cutting Edge of Same Tool.

stone smoothly, this edge of the tool must be straight without breaks or imperfections of any kind; and when even a small nick or break leaves a trace on the finished stone it must be removed from service for grinding.

The shape of the tool and the method of grinding have been established by a number of years use; and when the subject of alteration in any way is mentioned, stone men emphatically declare it cannot be done, explaining that the rake has a tendency to break off chips or spauls in front of the tool when taking a deep cut, leaving only a very small cut for the edge of the tool to finish. Our experiments have been conducted along the lines of improving these tools without changing their shape to any marked degree.

Mold or forming tools and tools for cutting checks and drips are made in a different shape. They are straight with the shank, not having the forward bend. The front of these tools is ground flat, with a clearance ground on the back very similar to metal-working tools of this character. Lathe tools are practically the same as those used with the planer, except that the bend or roughing tool is usually not so wide and has a more rugged construction and a shorter and greater bend. Mold tools for the lathe are very similar to the planer mold tools.

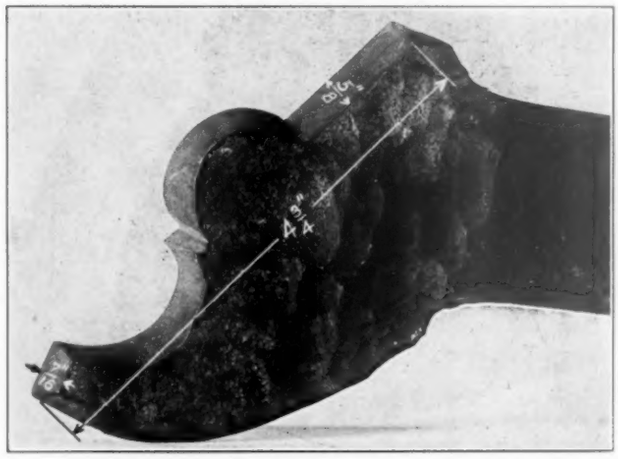
It is very important that mold or forming tools retain their shape. They are often made with delicate points projecting into the stone; and often they have square corners, as also is found with the tools for cutting checks and drips. These delicate points and corners are subjected to the frictional heat, which is not radiated quickly as is the case with larger sections, and the temper is drawn. Thus the corners break down quickly and then the tool often must be retempered; but sometimes only grinding is necessary to remove the untempered metal and place the tool back into service.

Probably the greatest of the factors that limit production in the machining of the harder grades of limestone is the tool. When carbon steel is used on these grades, they must be changed quite frequently, which alone requires considerable time. When the cutting edge wears round, we find that more pressure must be used to keep this tool at the proper depth in the stone. This pressure results in greater friction. The heat produced by this friction becomes a factor that affects both the tool and the stone. When the tool is continued in service the stone is burned,—that is, a film of burned stone or scale appears behind the tool—and the finish is far from satisfactory. If this heat is sufficient to penetrate the stone it causes an expansion and chips will be broken off to the depth of the penetration of the heat. Corners also will be broken off, this sometimes occurring several inches beyond the tool in the case of molds.

With this tool we have the same condition to a marked degree as is found in the metal-working tools except that we have the abrasive. The heat generated by friction draws the temper on a thin film on the tool edge. This condition is very similar to a reversal of case-hardening metal. The soft metal is between the stone and the temper metal of the tool. It is interesting to make a test with a file on these tools. A sharp file in being drawn across the edge of these tools will start in with rather a deep cut, but before it has passed very far it becomes apparent that it has cut down to the hard metal.

Using Carbon Steel Faced With High-Speed Steel

High-speed steel has been used for a number of years and has given very good satisfaction. The tests have shown as much as 200% to 250%, or even more, service over carbon steel, but the expense becomes an item for consideration when the entire tool is made of this material. Again, high-speed steel does not have the strength found in carbon steel, and many high-speed tools break in the shank and become a loss. Planer tools of an average size weigh perhaps 35 lb., and at the price of high-speed steel the tooling cost becomes a matter of consideration. In order to reduce the cost of these high-speed tools, shanks have been made



Tool For Cutting Irregular Shape in Limestone.

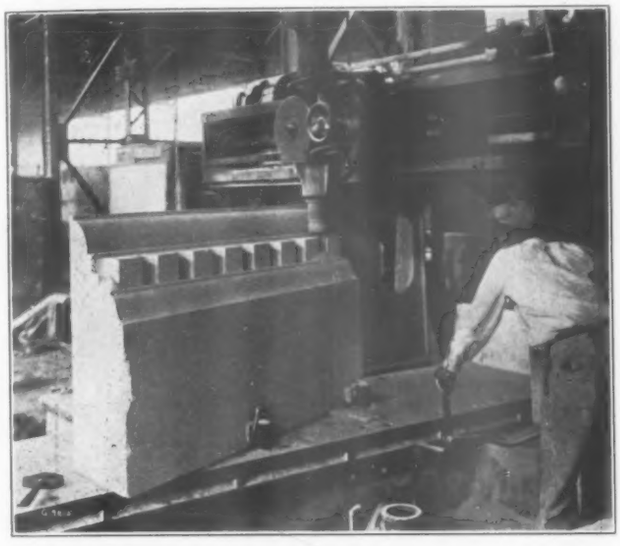
of carbon steel with the bits brazed or cemented to them. This method has proved fairly satisfactory, but the items of material cost and labor make the tool cost somewhat high. Unless an exceedingly good job of brazing or cementing is done, the high-speed steel which has been placed on the back of the tool is torn off and becomes a loss.

The alloys that we have tested include both the non-ferrous and the ferrous. We have had some success with both. We have conducted experiments placing the tools under as near like conditions as possible, using tools of as near the same size as possible and trying to give them the same working conditions. In the application of all these metals, we have found that oxide and other foreign substances on the tool were objectionable to its application and have endeavored to grind the tool and remove all these substances.

In the case of those grades of ferrous metals for acetylene application, all the manufacturers recommended the use of an excess of acetylene, stating that the carbon content should be raised. We found that a few of these alloys were softened by an excess of carbon. We had been warned of this condition, and

found it very advisable to follow the instructions in this matter very closely. We found that a soft flame, and one as small as was consistent to use in the work, was very advisable. When using an excessive heat it seemed that the elements were volatilized and results were not nearly so satisfactory.

In the non-ferrous alloys, we were instructed in all cases to use a carbonizing flame, and the results with these alloys were very nearly uniform. In all cases we were instructed to be careful not to dilute the alloy with the base metal. One company stated that this would not be of much consequence if not carried too far. In the case of the bent tool, we applied most of these alloys on the back of the tool to a width of about 2 in., this giving



Milling Machine.

(Cutter rotates about 80 times per minute for this size. Various types of tool holders are used and a large variety of designs are cut by these machines, saving a large amount of hand work. The "top" supporting the stone moves on slides or V-ways as a planer. In fact, this is a planer with a miller head and has been developed in very recent years.)

a greater service because the tool could be ground back farther than where the application was narrow.

One trouble we had with these metals was the difference in the relative expansion causing hair-line cracks across the metal. With some metals we have been absolutely unable so far to overcome this difficulty; and while these tools were placed in service and otherwise gave good results, except at the point of these checks, they wore back quickly to a V-shape. This condition is receiving the attention of the experimental engineers of the different companies, and at present it is being improved; and we feel that this defect will be overcome.

We find that the non-ferrous metals resisted the abrasion somewhat better than the ferrous, and except for chipping of the edge showed a greater resistence and were excellent on roughing cuts. Because of the manner in which this metal is placed on the tool, it has no support, and this is one of the worst features that we have to contend with. The metal is placed on the back of the tool directly opposite from the way it is used on metal-working tools; and in order to give most satisfaction it must have much strength to withstand the great strain.

Another factor that is very detrimental to metal of low tensile strength is shocks produced by slight vibration or springs on the tool and stock. These vibrations cannot entirely be overcome with present machinery, yet an effort is being made to reduce it on these tools by making them much heavier and giving them more bend and by fitting the stock much more closely.

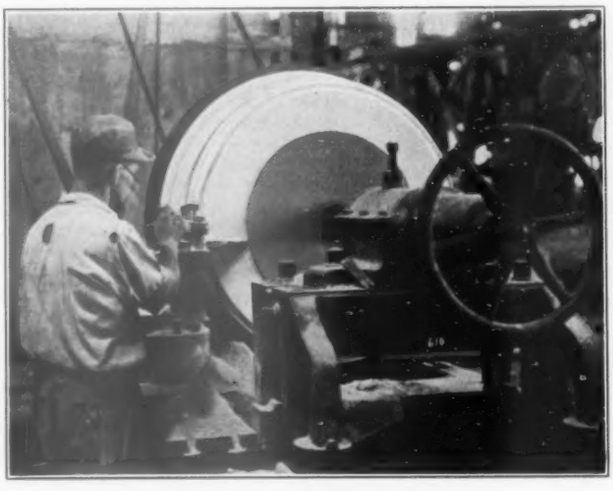
Still another factor is the hard deposits in the stone. With the non-ferrous metals we find these deposits striking the edge with a shock or impact and breaking out small chips. With the ferrous metals we find these less likely to chip from the above-named causes due to their greater tensile strength, but their resistance to abrasion is much lower. The edge of the tool is thin and the direction of force is almost directly across this delicate edge. The tool must retain an edge without chipping—one with an unbroken straight line.

Design of Hard-Faced Tools

Since the non-ferrous metals do not have sufficient strength to withstand this force, we have tried giving them a bevel on the back in order to give the edge more support; this gives them less clearance. We derived a great benefit from grinding in this manner; but when the tools become worn, much more pressure is required to keep them in the stone than when ground in the usual manner, as they have a tendency to slip over the stone. Here again the stone becomes the limiting factor due to the heat produced. Since heat does not soften these tools, due to their red hardness, they are unaffected; but when it is absorbed by the stone, we have the result that I previously described. However, with this method of grinding we have obtained very gratifying results.

With the non-ferrous metals we have tried both methods of grinding. Some of them gave better service than others with the bevel on the back, which is due probably to the fact that they have a higher temperature resistance than the others. The results of tests run on planers using straight grinding were not as good as when the grinding was changed, and by this change some of the alloys have shown as high as 300% to 400% service over carbon steel.

We conducted an interesting experiment on some rustic buff columns that were being turned in one of the mills. This lathe had been installed to turn columns of smaller dimensions, and the cutting speed could not be reduced on columns of this size to where the speed was within the range of carbon steel. Instead of taking steps to do this by mechanical changes, we tried the hard-faced tools to relieve this condition. The cutting speed in this case was about 46 ft. per min. On planers the cutting speed is from 28 to 36 ft., usually around 32 ft. These experiments were under my own observation and were checked as closely as possible. These columns were about 4 ft. in diameter, in sections ranging from 6 to 8 ft. in length This gives us a circumference



Turning Column Base on a Lathe.

of about 12½ ft. In one foot of tool post travel with a 3/8-in. feed, the tool would cut or pass over the stone approximately 400 ft. We prepared a number of tools to test on these columns. All these tools were used only on the roughing cut and were continued in service until they had finished the roughing cut on each section or until their condition necessitated taking them out of service. The results of these tests were as follows:

Results of Tests of Eight Alloys

No. 1. This was a high-carbon steel, very carefully prepared. It gave way and was taken out of service at about 14 in. tool-post travel. An examination showed that it had burned more on the inside corner but had broken down along practically its entire length. An examination of the inside corner showed that it had been very hot and was being badly upset. To put this tool back into service it would have been necessary to redraw, retemper, and grind.

No. 2. This was a non-ferrous alloy and was used to finish the roughing cut of about 8 ft., having traveled over the stone approximately 3,200 ft. Its condition on examination showed a number of chips on the edge extending back about $\frac{3}{16}$ in. Except for these chips, the edge was perfect enough for a finishing tool and had no appearance of burns. The steel was somewhat blued near the metal, showing that it had resisted the heat without giving way.

No. 3. This non-ferrous alloy finished an 8-ft. roughing cut with conditions practically the same as in the case of alloy No. 2. The tool edge was chipped, and the amount of grinding required to place it back in service was about $\frac{3}{32}$ in.

No. 4. This ferrous-alloy tool finished the entire roughing out but was somewhat burned on the inside corner. There was no chipping, but it showed a worn condition; and about $\frac{1}{16}$ in. of grinding was required to place it back in service. This tool resisted the friction heat to a high degree, but the effects were somewhat evident.

No. 5. This ferrous alloy showed a chipped condition throughout most of the edge. This chipping back was about $\frac{1}{16}$ to $\frac{1}{8}$ in. wide and extended back under the tool in some places about $\frac{3}{16}$ to $\frac{1}{8}$ in. The tool required about $\frac{1}{8}$ in. grinding before being placed back in service. We found that this tool had shown a softening on the inside corner as a result of the heat, and the stone that it had passed over showed a burn almost throughout the entire column.

Cutting Limestone With a Gang Saw.

(Tungsten carbide is being used in an experimental way with excellent results. Note the sloping slat work above the stone. These are the "spreaders" for the "slush" (sand and water) which is used as an abrasive for the blades. The blades are $\frac{1}{8}$x4 in. and long enough for the frame. They are stretched by means of taper pins shown in the illustration. These blades can be placed any distance apart for sawing slabs.)

No. 6. This ferrous-alloy tool finished the entire roughing cut. When it was placed in service it had small hair-line checks or cracks. These cracks when examined after test showed that corners had worn back about $\frac{1}{16}$ in. to a V-shape. Otherwise it showed a good condition when the test was completed, except for a very slight burn on the inside corner. Because of the worn condition at the hair-line cracks, it would have been necessary to grind this tool back about $\frac{1}{8}$ in., but otherwise very little "touching up" would be needed to place this tool back in service.

No. 7. This ferrous-alloy tool was out of service before the column was complete, having made a run of about 700 ft. It was badly chipped and broken, exposing the steel, which burned very quickly.

No. 8. This ferrous-alloy tool was badly broken at approximately 800 ft., exposing the steel, as in the case of No. 7, and was taken out of service.

This completes the number of metals tested on the lathe; it will be noted that the non-ferrous metals came through in somewhat better condition as to wear than the ferrous, except for chipping. The manner of setting the tool in the stock was to cut toward the face plate with the cutting edge at about 45 deg. Hence the inside, or right-hand, corner would be subjected to the greatest punishment. This is the corner where the tools were burned in the tests.

Courtesy Indiana Limestone Co.

The Tribune Tower, Chicago, Is a Fine Example of the Use of Indiana Limestone in Architecture.

Where Carbon Steel Tools Failed

Recently in one of the mills an order came through for a quantity of stone in pieces 6 in. thick by 20 in. wide and approximately 10 ft. long. In one side of these there was a drip or check 2 in. deep and 2 in. wide at the top, rounding down to a point. This was very hard stone. Carbon-steel tools were made for this job, but failed before cutting one-half of the depth. High-speed steel was brazed on the front of these tools, and these finished one check, or load, as the planermen call them—before requiring rgrinding. A non-ferrous alloy was placed on these tools and then as many as ten loads were finished before regrinding, the average being about seven loads. This was a great saving, owing to the fact that the peculiar shape of the tool made it impracticable to grind it a second time, as its size would be reduced so much that it could not be continued in service. We had no trouble with the edge chipping because the clearance was kept at the minimum, and the metal, being on the front of the tool, had plenty of support. A ferrous alloy was tried on a few of these tools and reports showed from four to five loads before regrinding was necessary.

With mold or forming and check tools, the clearance is ground on the back and we are able to place the alloys on the front of the tool. This gives the metal the much-needed support. The non-ferrous alloys have given most excellent results, and so far are superior to the ferrous. As regards the delicate points of

forming tools, we feel we have had our greatest success when they were not of such long slender shapes that we had springing. For this condition we have had better results from the ferrous alloys. With check tools, which are somewhat heavier, the non-ferrous alloys showed up much better.

It seems that records have not been made, or, if made, have not been kept, on the production cost of tools, so that we can only give you comparative costs with carbon steel as a basis. These tools weigh from 25 to 50 lbs. We find high-speed steel rather expensive when the entire tool is made of this material; and when bits are brazed or cemented on each tool, which is not always satisfactory, we find that the time required by a high-priced mechanic as well as the cost of the material amounts to large proportions when compared to the applying of hard-facing alloys. A check showed that these metals could be applied to a 12-in. tool for a width of about 1½ in. in approximately 8 min. For about a No. 6 or 8 welding head, the amount of gas consumed was found not to be great. The amount of metal would be about ¼ lb., more or less, depending on the thickness applied. With the non-ferrous metals it was determined that the cost would not exceed $1.50 for each tool of this size. We find that a much lower grade of carbon steel, one with just sufficient strength to withstand the strain, can be used to make up this tool, and the difference between the cost of this material and of the high-priced tool steel would probably amount to enough to offset the cost of application of hard-facing alloys.

Importance of Using Correct Grinding Wheel

The matter of grinding wheels and of the method of using them has been one Ethiopian in the cordwood. When experiments were first started, some suggestions were made as to the grade and the grain of the wheel, but these were not given much consideration. Tools were prepared and given to the tool grinder without much instruction, and he naturally used the wheel that was handiest, some of them being very hard and run at a high speed. This probably caused some downfalls. After a number of failures, this matter was taken into consideration and a check was made of tools ground on hard wheels. We made up some tools and gave them to the grinder. When these were ready for service we gave them a polish and examined them under a low-power glass. We found the edges very badly checked. These check lines intermingled to such an extent that they presented a granular appearance. We then tried a softer-grade wheel and found very few checks. I might add that the checks were very much less but present in all the non-ferrous tools examined. It was shown that too much emphasis cannot be laid on the type of wheel and the manner of grinding for these metals.

One condition we have found to have a bearing on the result of these tests is the attitude of the men who use the tools. We have also found that where men have been educated to their use, these tools are more in demand. The results obtained are much better than when the same tools are placed in the hands of men who have the "doubting Thomas" spirit. An educational program will give great results in a condition of this sort and should include everyone having to do with the use of these tools from the superintendent down. It would remove all negative influence and create an open-minded atmosphere for improvement.

The tremendous disadvantage under which we have placed these alloys and the results we have had are very convincing of their abrasive-resistance qualities. We have proved that they retain their hardness at high temperatures at which carbon and high-speed steels give way. Their ease of application is an outstanding factor that will appeal to every one. With all these qualities it seems a safe prediction that in the near future their use will become an economic practice that will be a vast saving to the various industries.

In conclusion I will say that we appreciate the wonderful co-operation that we have received from the various organizations and we can recommend their services and advice to any one interested and in need of hard-facing alloys. While we have not accomplished our aim, we feel our problems will be solved in the near future because of the fast developments in this field.

CUTTING TORCHES DO SPEEDY WORK IN EMERGENCY JOB OF BRIDGE OPENING

The Pennsylvania Railroad bridge over the Hackensack River between Greenville and Port Newark, N. J., was to be replaced by a new structure erected alongside the old. As the old bridge was of the swinging type, it was necessary to cut almost half of it down to permit the closing of the new bridge, and the job had to be completed in 4 hr., as that was all the time the railroad would allow the main freight-line traffic to be stopped.

The old bridge was turned at 8:20 a. m. and the new bridge closed at 12:05 p. m., a time interval of 3 hr. 45 min., which was made possible by the use of cutting torches.

Fourteen cutting outfits were on the job. At times all of them were cutting, and at no time were less than eight of them in action. Both K-G and International Oxygen Co. torches were used.

The new bridge is of the lift type recommended by the War Department and similar to the one owned by the Central Railroad of New Jersey and the Delaware & Lackawanna Railroad and spanning the Hackensack River. The section over the channel when fully elevated is 119 ft. above high-water level.

The contract for the new bridge was held by the Henry Steers Co., of New York City, and the removal of the old structure was sub-let to the Jobson-Gifford Co., also of New York City.

WELDED BARGE NOW IN SERVICE

The all welded barge, named the Steelweld, designed by E. H. Ewertz, a past president of the American Welding Society, and built at Groton, Conn., by the Electric Boat Company, attracted wide attention from navy departments and marine architects when it was recently launched. The general

Launching of All-Welded Barge.

construction features of this boat were illustrated in a previous issue of *The Welding Engineer* at the time work was started on it. Use of arc welding in this construction is reported to have resulted in a saving of 20% in the total cost of building and 25% in weight and time required for construction. Maintenance cost is likewise reduced by almost one-fourth. Leakage of liquid cargo around corroded or sprung rivets will also be eliminated. Ship builders consider this last point very important because it has been estimated that about 3% of their liquid shipment is lost in transit through such leakage.

NEW OFFICERS OF C. G. M. A.

At the annual meeting of the Compressed Gas Manufacturers' Association, held on January 28th at the Hotel Astor, New York City, the following officers were elected for the ensuing year: President, J. R. Colby, of Canadian Carbonate Ltd.; 1st vice-president, E. C. Turner, of the Air Reduction Co.; 2nd vice-president, H. W. Cole, of the Liquid Carbonic Corp.; and secretary and treasurer, F. R. Fetherston. The annual dinner, held in the North Ball Room of the Hotel Astor, was very successful: favors and door prizes were donated by various companies and individuals.

LARGE CONSTRUCTION FIRM OFFERS ITS CLIENTS ARC-WELDED FABRICATION

Noiseless construction for large industrial and commercial buildings as a practical proposition for the first time in the history of the American building industry is seen in the announcement of The Austin Co., of Cleveland, Ohio, internationally known firm of engineers and builders, that the electric welding of structural steel is to be offered as a regular part of its service. The company will make welding or riveting optional.

Inauguration of the welding process is the latest step in the company's expansion program for 1930, according to W. J. Austin, president. The innovation followed years of extensive research and it marks the passing of electric welding in construction from the experimental stage to a position of commercial importance.

The company's plans provide a 50% increase in the facilities of its steel fabricating plant at Cleveland to permit installation of electric welding equipment. Announcement of the company's plans is expected to arouse much interest in the building industry throughout the country.

In the past, welded as against riveted construction has been employed on a more or less experimental basis. It never before has been offered as an optional proposition. Engineers of The Austin Co. have conducted exhaustive tests over a period of eight years which have convinced them that welding is destined to have a substantial place in the fabrication of structural steel. Welded and riveted steel trusses were tested to destruction, and five years ago a building equipped with a heavy-duty crane was constructed by the company at Pittsburgh.

Two years ago the company pioneered in the construction of the first large commercial building in the world to be completely welded. No rivets were used in this building, which is an office structure located on Carnegie Ave. in Cleveland.

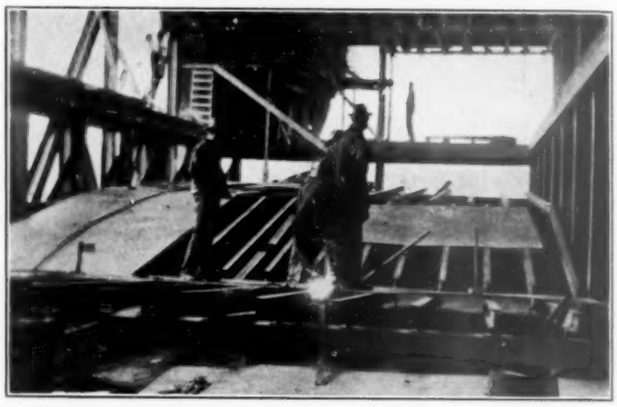
Equipment now in transit to the company includes not only the machines to be installed at the plant, but complete field welding equipment for use on Austin construction in any part of the country. At the fabricating plant the company will apply straight-line production methods to the welding of steel building sections.

"We are convinced that electric welding is here to stay," says an official of the company, "and that it has a substantial place in building construction, along with the older method of riveting. In the future we will be able to supply owners with either service. For buildings in hospital areas and in many other places where silence is desirable, electric welding has undoubted advantages, and there are many other conditions under which builders may desire to use it. Welded steel building framework is actually a one-piece structure, as the various members of the structure are fused together at the joints. The strength of this construction permits as high as a 15% saving in structural steel."

SWIMMING POOL OF WELDED STEEL

By J. C. Coyle

A swimming pool that is different from the usual construction in that it is built entirely of steel, with a waterproof coating of Gunite and Elaterite compositions, and all joints are welded, has been constructed on the fourth floor of the new home of the Young Women's Christian Association, Tremont Place, Denver, in which the offices of the Association, a cafeteria, auditorium,



Welding Steel Sheets That Form Floor of Swimming Pool.

gymnasium, and all other activities of the Association are housed under one roof.

The pool is 24x54 ft. inside and the depth ranges from 4 ft. at the north end to 9 ft. at the deepest place, near the south end. The sides and bottom of the tank were formed of 7x8-ft. sheets of ¼-in. steel, laid on 5-in. I-beams spaced 2 ft. apart and placed lengthwise of the pool. These I-beams rest upon heavy steel beams varying in size with the depth of the pool. In order to support the immense weight of the tank when full of water, extra-heavy columns were used in that part of the building structure beneath the tank.

THREE NEW SAFETY POSTERS ON WELDING

The National Safety Council, 108 E. Ohio Street, Chicago, Ill., has had printed for the members of the Council 3 new safety posters, size 9x12 in., that tell effectively by pictures the correct way of handling gas tanks for welding and the safe way to open the valves of oxygen tanks. These posters, shown in the illustrations, are attractively designed in colors, and are an important addition to the Council's series of posters pertaining to the welding field.

Courtesy National Safety Council

Courtesy National Safety Council

Courtesy National Safety Council

Practical Side of Structural Welding*

How One Steel Fabricating Shop Successfully Met the Problems Introduced by the Adoption of Welding for Jointing Rolled Shapes

By A. L. Wilson†

THE late Professor Ira O. Baker of the University of Illinois defined engineering as the directing of human endeavor in the use of the materials of nature for the benefit of mankind. The way to approach an engineering problem, said he, is, first, to find out just what you have to accomplish; second, find out how many ways it can be done; third, find which is the best way; and fourth, do it that way.

We need to approach welding as an engineering problem. The retarding factor in the advancement of welding in the structural field is the lack of logical study of each problem. Can you weld it? Can you rivet it? Considering time allowed to fabricate, strength and cost, which is the better way? Where's the man with experience enough to tell you?

We have had in the past the militant advocate of welding who said that in five years there would be no rivets driven. This man would look at the plans of a job and say off hand, "Weld the whole thing."

Then, on the other hand, we had the man who thinks that welding is a glorified method of soldering.

We not only had them, we still have them.

What we need is men with a good supply of horse sense, a thorough knowledge of welding and its adaptability, together with an accurate conception of shop costs. Then by studying

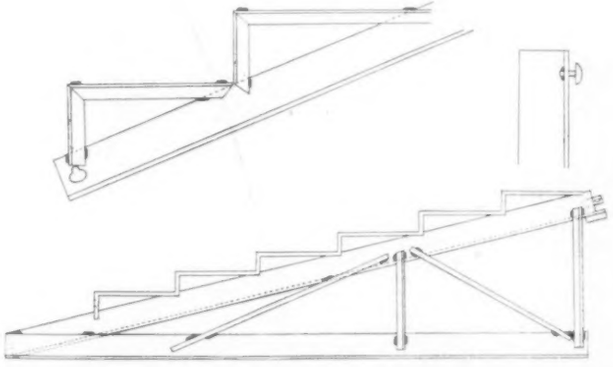


Fig. 1. General features of design followed in construction of portable seats for the Harmon Stadium. The small sketch in the upper right hand corner shows how a welded stud is provided for assembly, this stud fitting into the slot shown at the bottom of the sketch at the left of this.

the different types of work on the job with an open mind, they can decide where welding would be of advantage either by itself or in conjunction with riveting.

The man in the shop is most likely to understand the adaptability of welding. He will undoubtedly have the greatest faith in it. But beyond his belief in it he must understand the changes in design necessary to make welding show a profit. Then he will have to do the pioneering work with the engineer and the draftsman.

You cannot take a riveted design and simply weld it together instead of riveting it and save any money or even do it as cheaply.

Two Examples of Work Where Welding Was Necessary

We have one class of jobs that call for welding. These are the jobs which for some reason are not adaptable to riveting. I have in mind two jobs that come in this class. One is the seats in the new Chicago Stadium on Washington Boulevard. One night there would be a prize fight at which the seats would be used, and perhaps two nights afterward there would be a hockey match, requiring that the floor be cleared. To do this the seats had to be put on supports that would be light and also that could be stored in a small space. A riveted job with the connecting clips and gussets was bound to be heavy and more or less cumbersome. On this job there was 45 tons

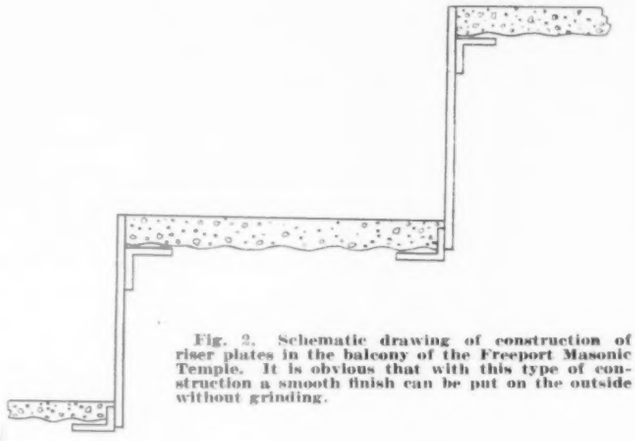


Fig. 2. Schematic drawing of construction of riser plates in the balcony of the Freeport Masonic Temple. It is obvious that with this type of construction a smooth finish can be put on the outside without grinding.

of welded seat supports. Besides giving better visibility, the welded construction increased the main floor seating capacity by 600 seats. The general features of design are shown in Fig. 1.

The other job I have in mind is the riser plates in the balcony of the Freeport Masonic Temple. These plates were curved and exposed, requiring a perfectly smooth finish, to obtain which the rivets would have had to be countersunk and chipped and then ground. There were about two hundred of these plates. We bent the angles, and pulled the plates to them in a jig we welded out of scrap. Fig. 2 illustrates the construction.

It is one thing to have the advantages of welding pointed out after the job is done, and another thing to find them before the job is started. The fundamental requirement of any process it that it shall be as good as another and at the same time cheaper.

The two main items in the cost of a structure are material and labor.

Three Ways in Which Welding Saves Material

As regards material, I believe you can save on the average about one-seventh of the weight by welding. This saving comes in three ways.

In tension members you do not have to allow for the metal punched out. In trusses that would permit you to use the next smallest angle in many cases. For example, if you need a 4x4-in. angle for riveting you might use a 3½x3½-in. angle for welding.

A great many structural members that are much bigger than they need to be for strength are used merely to have enough room to get the rivets in. In the case of welding you can cut these down.

*Paper read before the November 7, 1929, meeting of the American Welding Society, Chicago Section.

†Mississippi Valley Structural Steel Co., Melrose Park, Ill.

The third way of saving material has not yet been used to any great extent. This is the possible saving due to continuity. For example, if you weld a beam to a column and also weld one right opposite to it on the other side of the column, you can consider that the two beams act as one continuous beam. This permits the use of a smaller beam.

Then too in the case of welding you can consider beams as having absolutely fixed ends, this reduces your bending moments and allows a smaller size of beam.

It often happens that the only saving you will get by welding is the saving in material, but this is worth while.

In order to take advantage of welding, the designers and draftsmen must be "weld minded." Having had the methods and details of riveting drilled into them for years, they have a tendency to design welded parts by merely substituting an inch or so of weld for each rivet.

In considering the savings that welding makes possible in fabricating, one needs a thorough understanding of the different steps in producing the finished piece. Just because one man is welding while four men are needed on the rivet gang, it doesn't follow that the cost of welding will be one-fourth the cost of riveting.

Conditions Under Which Welding Is Cheaper Than Riveting

In the usual course of fabrication, the steel has to be marked, punched, bolted up, and riveted. It has been my observation that if you can save sending your piece to the bolt-up and rivet floor, you will be able to weld it at least as cheaply as you could rivet it. And if you can add to this the saving you get by not marking or punching it—that is, send the steel directly from the cutting department to the welders and let them fabricate it—you will in most cases show a saving by welding. *IF* there is some simple way of placing the pieces in their proper position and holding them while you do the welding. There are many cases where the making of jigs to hold pieces while they are being welded offsets the other advantages of welding them.

That is one decided advantage that riveting has over welding. In riveting you can bolt the pieces together and partly tighten the bolts and then drive your pieces exactly square or to the right bevel. In welding you have to hold the pieces together with clamps and they tend to slip if you try to drive them. Where the number of similar welded parts is sufficient to warrant it, you can usually make a jig out of scrap to hold the pieces together.

Then there are certain definite savings on special operations. Take the matter of countersinking and chipping rivets where a smooth surface is required. In most cases a way can be devised to weld the pieces so that countersinking and chipping are avoided. A great many sharp bends or difficult twists that ordinarily take a long time to form can be made easily and cheaply by welding two or more separate pieces together, or by burning or cutting out a notch and after the piece is bent welding the crack up.

In the case of elbows in flues, welding saves the expense of laying out the holes and punching them in the plates before they are rolled. Unless one has a lot of work of this type it takes quite a while to get the holes so that they come exact after the pieces are rolled. It is fairly easy to make elbows by welding, even up to 10 and 12 ft. in diameter. There is a little trouble in lining the sections up, which can be avoided by employing bolt holes. Probably the most economical way to make flues is to weld the elbows and rivet the straight sections.

To summarize the matter of designing for welding: Start, if you wish, with a riveted design and study it to eliminate metal used merely to provide connections for riveting; to eliminate several handlings of a piece by having all the work done at the welders; and to eliminate special work that costs extra; and then don't try to weld something that can be made cheaper and better riveted.

Strength In Weld Design

We have not yet considered weld design from the standpoint of strength. There is just one point that is fatal from this standpoint, and that is designing the weld so you get a bending against the weld instead of having your weld in tension or shear or compression. This has to be taken into consideration not only as regards the stress on the piece after it is erected, but also any stress it may get in shipping or erecting. Fig. 3 illustrates this point.

The best way to arrive at a unit stress value of your welds for use in estimating the amount of weld needed, is to have your welders make some welds and then see how much it takes to break them. We use a $\frac{1}{8}$-in. bead in most of our work and find it holds from 5,000 to 7,000 lb. per lineal inch. You can compare test values with what your men get to see how they compare with the experienced welder. If you use values that your men are actually capable of attaining you will always have enough and can cut down on the amount as the men become more proficient. Our welds today are about 50% stronger than they were three years ago. This is due in a large measure to the improvement in the welding wire.

If you have work properly designed for welding, the next thing to consider is the method to use in getting it out. You have to take into account material, equipment, operators, their training, means for holding the work, and inspection.

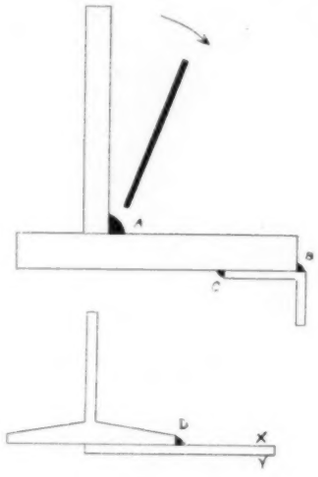


Fig. 3. Illustrating strong and weak features of fillet welds. Rotation of the top plate in the direction of the arrow would cause failure of the weld at "A." Heavy black line indicates proper slant of the electrode. The small tack weld at "C" will prevent weld "B" from being broken by accidental bending in the wrong direction. A blow on the lower plate at "X" would not injure the weld "D" but a blow at "Y" would easily break it .

Our material at the Decatur and the Chicago plants is all under cover. It comes to the welding floor practically free from rust and requires no special preparation before we weld it.

There are many good and satisfactory makes of welding machines. We have found the short-arc machines better adapted to our work than the new machines that will carry a longer arc. The helmets that hinge up and over the head are best adapted to our work, as they permit the operator to use both hands and by a shake of the head to bring the helmet down when he gets ready to start welding. However, be sure that you get one with plenty of head room, as some of them bind the head or rub the ears.

We make our own electrode handles. They are heavier than the ones on sale, but stand up a great deal better. By putting beveled grooves in the jaws we get a very firm grip on the wire; these grooves also keep the wire from twisting around if it sticks.

There is considerable argument about the effect of the flashing of the arc on workmen on or near the welding floor. We have very little trouble with flashing unless a man is working within 10 or 12 ft. of the welder. Movable sheet-iron screens or cardboard is used when the welders have to work close together. We have found that light-weight goggles under the helmet give better protection to the welders than screens, when working near each other.

For fit-up men working around the welders, any kind of goggles will protect them as long as they don't look directly at the arc. Several of us use our spectacles as protection by putting pieces of cardboard on the bows to keep the light from coming in the sides.

Laying Out Structural Work

For structural work you need a large plate on which you can make layouts, placing your pieces on the layout for welding. You will also need a floor of some kind to which you can clamp trusses, lintels, beams, struts, etc. This floor should be solid to permit pulling the pieces into place. We have a very satisfactory floor made by laying 8-in. beams, about 10 ft. long, on 3-ft. centers across two 9-in. stringers. If you run a line the length of your floor about a foot in from the ends of the beams, and lines perpendicular to this one down the center of your beams, you will save a lot of time in laying out frames, doors, etc., that require right-angle corners.

You will find that you need clamps with a coarse thread, perferably a square thread, as the little globules of weld metal fly and stick to fine-threaded clamps and very quickly put them out of order.

We have found it best to train our own men. If you get hold of a welder who doesn't know how to weld, but thinks he does, it is very hard to teach him much. Acetylene burners seem to very adaptable as arc welders.

One point not sufficiently stressed in welding instruction books is the importance of being comfortable. A man must be at ease to weld. Bracing the knee or elbow against something solid helps to steady the body and reduce the strain of trying to hold oneself still.

Especially in the case of beginners, the cable should be drawn over the shoulder and just enough slack left to allow the holder to be moved back and forth. The weight of the cable when resting on the ground gives a pull on the wrist as the electrode handle is moved, which interferes with holding the handle steady.

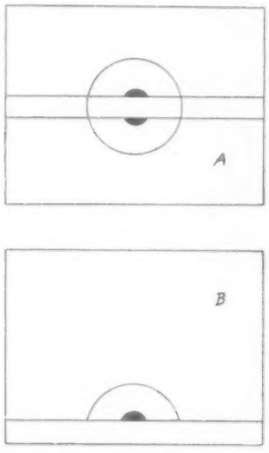


Fig. 4. Illustrating why both parts of a fillet weld of the type shown at the top of Fig. 3 should not be heated equally. "A" shows the heat conduction in the lower plate and "B" the heat conduction in the upper plate.

It is very hard to tell what path the current will take. Sometimes you should weld toward your ground and sometimes away from it. The surest rule is always to follow the little ball of flame at the end of your wire. If you hold a short enough arc you will see a little ball of flame that tends to go one way or the other. If you follow this you will get a good, clean, sound weld. If you hold too long an arc your flame will jump around and you may not be able even to locate it. The reason for following the flame is that as it precedes the actual deposition of the weld metal it heats the base metal up to a considerable extent before you weld it; and if you let the flame go back over the weld that is already deposited it carries gases and impurities into the weld. The actual manipulation of the arc is much easier when following the flame.

Another point in welding is to keep your wire moving slightly from side to side even when you do not require a large enough bead to require weaving the weld. When you are welding in a corner, if you try to hold your wire steady and it swerves a little, it may stick or it may get too far away and break the arc. But if you have a constant motion to it you will recover your arc or draw it away before it has time either to break or stick.

Obtaining Equal Heat On The Parts to Be Welded

In many welding operations the pieces to be welded are of the same thickness, but in structural work they are usually of different thicknesses. For example, you may have the edge of an angle to weld to the center of a plate or the flange of a beam. In other cases you may have the edge of a plate to weld to the center of another plate. It is important that you melt both pieces about equally, and this cannot be done by playing your arc on both equally. The explanation of this is very simple. When you play your arc on the center of a plate the heat is conducted outward in a circle—that is, over an area of 360 deg.—and dissipated about twice as fast as when you play your arc at the edge of a plate, where the heat is conducted outward in a semicircle. This is illustrated in Fig. 4.

When welding light angles to beam flanges, we play the arc on the beam near the toe of the angle and the angle heats up enough to melt without the arc being played directly on it.

If you can get a man who can hold a steady arc and will pay attention to his work, to follow the arc and play it on the piece hard to heat, you will in a short time have a good welder.

In the matter of heat it is a rather general idea that the hotter the arc the better, as it gives more penetration. This may be true in the hands of an experienced man. However, it also permits the holding of a longer arc, which gives a porous weld. This is often hard to detect in the finished weld.

I have been unable to substantiate the theory that a higher heat produces speed. On the other hand I did not find that it made a weaker weld when used by an expert welder. In welding structural shapes we find an amperage between 150 and 175 to give the best results with 5/32-in. wire.

When we consider the matter of fabricating structural steel we have one thing to contend with that a lot of other users of welding are free from. In the structural field a large number of the pieces are different and each job is different. We cannot take a special operation and study it to eliminate lost motion and to find the quickest methods of production, except in a general way.

In the first place, the main question is whether you are going to have a man clamp the pieces in place ahead of the welders or whether you are going to let the welders fit up the steel as they go along.

There are several objections to having a fit-up man. You have to have plenty of room so that he can fit up pieces in one place while the welder is welding them in another. The welder has to produce about twice as much work with a fit-up man as without to pay for having him. We have never been able to speed up the work with a fit-up man to pay for the added labor cost. Another objection is that while on one job a fit-up man may be able to fit up for three or four welders, on another he cannot fit up for more than one.

One advantage in having a fit-up man is that any good blue-print man can do this work; but only a few welders take enough interest in advancing themselves to learn to read blueprints, as there is plenty of work to be had in merely welding.

We have found that the best method is to let the welders fit up their own work, but have a good blue-print man to check it before it is welded, figure out and construct jigs where there is duplication, and fit up complicated pieces. The fit-up man has also picked up the use of the arc so that at times he does the actual welding.

Methods of Assembly and Welding

Some of the methods we use will be described, in the case of columns we mill both ends of the beam or H, then mark

the center on the web and flanges and put the center lines on the plate. The welder then holds the plate on center while he "sticks" it with the other hand. Care must be taken to see that it is "stuck" in enough places so that the weld in cooling will not pull the plate away on one side. Fig. 5 shows such a column construction. One thing that should be looked out for is that when a weld cools it shrinks. If you weld all along one side of a piece without tacking down the other side, when you get to the end you may not be able to get the other side pulled down. When you weld an angle frame to a plate to make a door, if you do not tack it and then first weld one side and then the other your door is likely to warp.

In making beam and plate lintels we put the plates down on our welding floor and after the beams are set on top we clamp the two together wherever it is necessary to get contact.

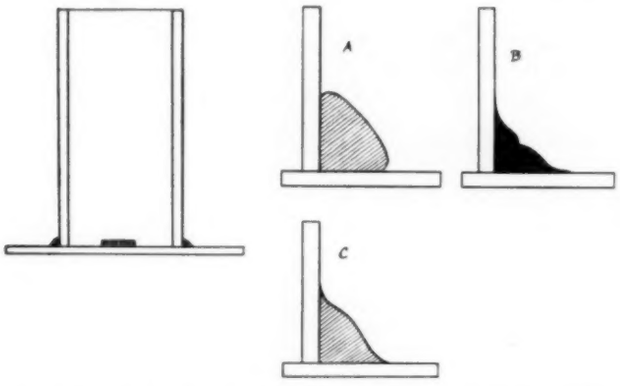


Fig. 5 (Left). The design of weld of H-beam to plate in the construction of column.
Fig. 6 (Right). Cross-sections of different types of weld deposits. "A" is made with too little heat; "B" with too much heat and "C" with the proper heat.

If a beam is sprung a little you can often clamp it over into place without sending it back to be straightened.

In making ladders we punch the holes for the rungs $\frac{1}{8}$ in. oversize and cut the rods $\frac{1}{8}$ in. short. By using a stick of wood the proper length for a separator, we space the bars, then "stick" the rungs and weld them on both sides of the bar.

To weld angles on the webs of beams or bars on the backs of channels edgewise, the easiest way seems to be to pull them down and hold them while a welder "sticks" them. In pulling flues into place and plates against beams on bulkheads and dam gates, the pieces can be gripped by welding on temporary bars.

We frequently use wooden blocks to get our spacing, instead of measuring each time. The distance of an angle back from the edge of a channel or the distance of anchor bars on curb angles from the back of the angle can easily be measured in this way.

Odd work for the welders consists in welding mispunched holes and flaws in the steel.

We often replace broken castings and small parts with welded scrap. Our blocks for bending, crimping, and flattening are all made up out of welded plates. Some of the spacing tables on the punches are all-welded and all of them are partly welded. The motor supports at the machines are mostly welded, as it is very easy to clamp a platform to a column or hang it from a truss and, after it is in the right position, to weld it there.

We weld small jib cranes for operating over our machines without having them drawn or laid out. In one case we wanted a 5-ton crane over an end miller. We just fastened the crane beams to the under side of a portal bracing and welded in enough more members to give a truss construction to the bracing.

We drill very few holes around the shop for maintainance work. It is easier to send a welder over to "stick on" whatever is wanted.

There is considerable argument pro and con as to whether a weld can be inspected. A good, sharp blow with a 12-lb. sledge hammar right at the weld will break a poor weld. You can measure your weld with a gage to see if it is up to size. A good weld can be told, also a hot or long-arc weld and a cold weld. A long arc spatters the weld metal instead of depositing it at one point.

As to the argument that there maybe a short space underneath your bead that has not penetrated, you are no worse off than when you have a rivet with the head way off center, or a badly burned rivet, or a connection one part of which has a slotted hole.

Making Welded Truss Design More Economical

We have experimented a good deal in the building of welded trusses. We have had to do things that seemed foolish to us to satisfy the engineering department. But as they saw the trusses tested, we were able to make them believe in the strength of welding and finally evolved the welded truss as we build it today.

At first we ran the bottom chord beyond the top chord and heated it up and bent it back over the top chord, as shown in the top diagram in Fig. 7. We also put in a reinforcing plate at the end of the truss similar to a gusset plate; this was considerable trouble and expense.

About this time we built a truss-testing machine. It consisted of a row of 7-in. I-beams set at 3-ft. centers along the wall of the welding room. These are securely anchored at the bottom. On each column is mounted an air cylinder 8 in. in diameter. These cylinders give a pressure of 5,000 lb. each

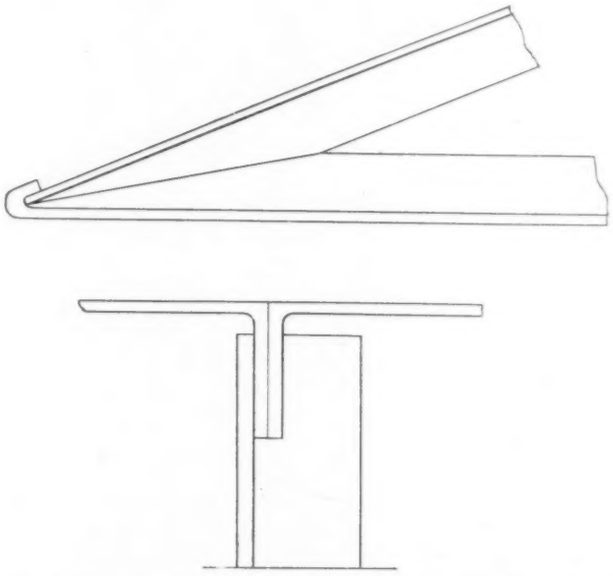


Fig. 7. Truss construction shown at the top was abandoned because it was found entirely unnecessary. The lower sketch shows the end of a web member slotted to slide over the chord.

with an air pressure of 100 lb. per sq. in. in the supply line. By placing the trusses against the base of the columns we can adjust the cylinders so their pistons bear directly on the top chord of the trusses. In this way we get an actual uniform load equal to about one and a half times the designed loading on a 40-ft. truss.

Instead of welding the complete joint at the heel of a truss, which would amount to 15 in., we welded 3 in. on each side and then put it in the testing machine. The top chord humped up at the heel, showing that there was plenty of strength without bending the bottom chord up or putting in a gusset plate. Since then we have left out the gusset plates, except on trusses of 80 ft. more or less, where they are required for vertical shear.

Another argument advanced by the engineers was that if we put the diagonal web members, in with the tension members on one side of the truss and the compression members

on the other, the two top chord angles would tend to slip by each other, as there would be a push up on one side and a pull down on the other. So for a long time we slotted the ends of the web members and slid them over the chords, as shown in the lower diagram in Fig. 7.

Bending the Top Chord

To bend the top chord, we first weld the two angles together. It takes a weld about every 2 ft. along the toe and every 5 ft. along the back of the angles to hold them when being bent. In this way the chords are held together very tightly and we finally discontinued slotting the web members.

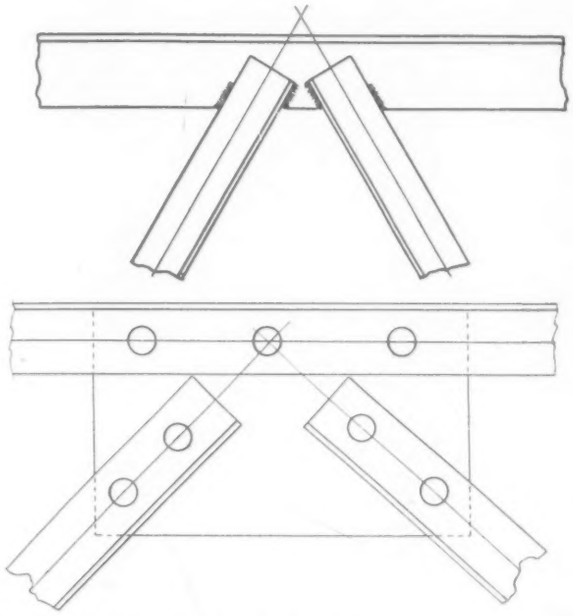


Fig. 8. Illustrating the intersection of the gage lines in welded and riveted construction.

Technically, there is an error in the design of these trusses, in that the centers of gravity of the web members do not all intersect in a point on the center of gravity of the chord angles. Therefore there are unbalanced forces at the joints which are not present in a riveted truss where the gage lines all intersect in a point. I could never see much reason for worry on this question because, first, the web members in a curved chord truss theoretically have no stress, and second, while the gage lines on a riveted truss intersect in a point the stress is carried through the rivets and does not by any means follow the gage lines, as Fig. 8 illustrates.

We make a complete line of welded trusses. Up to 40-ft. span, we make them in one piece. Between 40 and 65 ft. we make them in two identical halfs; one half is turned around and fits on the first one.

In welding these trusses, we place special clamps on the welding skids in the form of the finished truss. These clamps pull the top chord into place if it has not been bent exactly. The web members are laid on the chords, every other one being clamped underneath. These trusses will take a 2-ton load on the bottom chord at any panel point; they are very satisfactory for garages, hoisting equipment can be hung from them.

We tried one lot of trusses with the chords made out of T-sections made by splitting a 12-in. and a 15-in. I-beam longitudinally through the center of the web. The beams were easy to split, as we put them on the automatic welding table and ran them under a torch. We burned them at the rate of 42 in. a minute, which was faster than what is ordinarily considered to be the maximum speed for burning. At first we had trouble with the beams warping as we burned them. But we overcame this by leaving a foot uncut at each end, and after burning the rest coming back and burning this foot by hand.

This method of building trusses proved unsatisfactory, owing to the trouble in getting the top chord bent exactly. When they were off line a little, it was very hard to pull them over into place, while, on the other hand, the bent angles are easily pulled into place.

Effect of Galvanizing On Weld Strength

At one time we considered welding electric substations. One argument against this was that the galvanizing might weaken the welds. We took eight pieces and had half of them galvanized and the other four left ungalvanized. They were all made at the same time by the same welder. There was one ungalvanized piece that was stronger than the weakest galvanized one. Otherwise the galvanized pieces averaged about 7% greater in strength. At least galvanizing does not weaken welding, and it might be possible to prove that it even has an annealing action.

We never welded up any substations, however, as we would have lost more trying to locate the details than would be saved.

Later the engineers raised the question whether in welding the heels of two angles together enough penetration could be obtained to give a weld of any considerable strength. We welded two angles together this way (Fig. 9) with a weld just 1 in. long, and it took 6,000 lb. to break it in tension.

We next tried building channel struts, using a bent rod in place of lacing bars (Fig. 10). This would be feasible if the rod isn't too big. The bending has to be true in order to fit between the channel flanges and leave the backs straight and the right distance apart. We had a ¾-in. rod, which was too heavy to bend by hand or by any machine we had at that time.

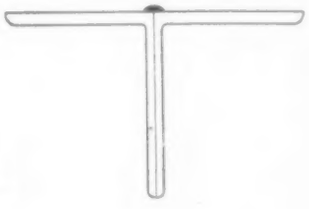
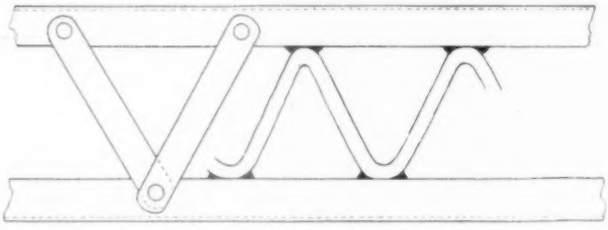


Fig. 9 (Left). A weld of this design (1 inch long, ⅜-inch bead) withstood a pull of three tons.

Fig. 10 (Below). Suggested design of struts made up by welding. A typical riveted design is shown at the left.



When we got through we loaded up a riveted and a welded strut together. As they were on the boltup floor, we did not have enough head room to get a destructive load on them. The welded strut was a little bit stiffer than the riveted one. With a little experimenting to cut down the size of the rods so that they could be bent in an air bender, I believe this type of strut could be made welded.

Up to this time all our welding had been done by hand. After the General Electric Company brought out their automatic welding heads, Mr. G. A. Caldwell, vice-president and general superintendent of our company, thought there ought to be a way to automatically weld much of our work. He worked out a machine for doing this.

Machine For Automatic Welding of Structural Steel

This machine consists of a table 65 ft. long with rolls 3 ft. long set between channel stringers, one every 5 ft. These roll-

ers are motor driven and carry the material between the welding heads. Referring to Fig. 11, the welding heads, of which there are two, are fastened one on each side at the center of the machine. Just before the material gets to the welding heads it runs through several sets of guide rolls which line it up and hold it in place. Right over the center roll is a hold-down roller that forces the two pieces together just before they reach the welding heads. The machine is controlled by a commutator on the drive shaft which can be set to give you welds of from 1 to 6 in. in length, and spaced from 3 to 27 in. apart. The welding heads can be staggered, giving alternate welds, first on one side and then the other. Either or both heads can be operated continuously or intermittently. This permits a continuous weld at the ends of girders or at the bottoms of columns. Bl throwing a switch, the operation can be changed to alternate welds. When the machine is welding the table travels about 4¼ in. per minute. When the weld is completed the welding heads automatically shut off and the table travel speeds up to 40 ft. a minute. After it has traveled to the place for the next weld, the table slows down again and the arcs turn on.

We have run plate and beam lintels through this machine at very little expense. While the machine welds the lintel, the men take off the finished piece with a hoist and arrange on the table the material for the next one.

The biggest single job put out on this machine was the girders and columns for the warehouse and shipping yard at

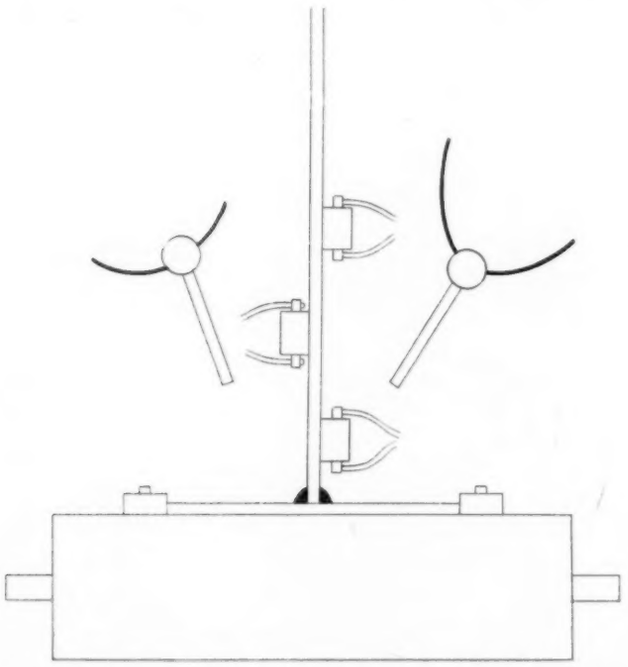


Fig. 11. Schematic diagram showing the arrangement of roller guides and automatic welding heads for shop fabrication of girders, columns, lintels, etc.

our Chicago plant. The plant is located just north of Lake St. at 25th Ave., in Melrose Park. This warehouse is 340 ft. long by 135 ft. wide. It has a 20-ton crane running its full length. The roof trusses are welded 80 ft. in length.

Design of Welded Pile Drivers

During the past year we have experimented with a new type of welded work. We have built six pile drivers for Walsh & Masterson, of Chicago. Each has a square lower base that supports a circular rail. An upper base rests on a roller nest that rotates on the rail. The rear end of the upper base supports the boiler and engines; the front, narrowing down to a width of about 3 ft., supports a 75 ft. tower at the end, which permits the driver to get into corners. The whole machine weighs about 21 tons.

In making these drivers, the beams that comprise the base were taken directly to the welding floor from the cutting department. The fit-up man laid them out and burned the copes and bevels on them. They were then tacked in place. The beams were continuously welded at all joints, which was probably not necessary. The H-columns that form the leaders for the tower were laid horizontally; after they were squared and leveled up, the trussed framing that forms the back of the tower was built right on them.

We have done several jobs of stiffening beams and channels, by welding bars against the webs instead of using riveted stiffner angles. We have had two jobs of girders where the

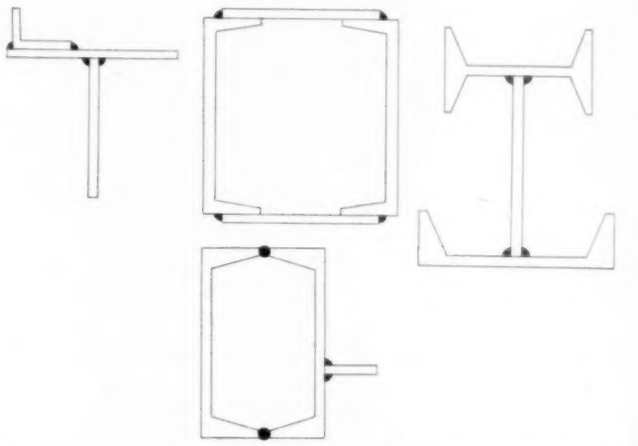


Fig. 12. Some of the structural assemblies produced by automatic arc welding.

stiffners were welded at the top instead of being milled and fitted. It seems likely that the use of welding in this connection will steadily increase in the near future.

Printed information on the use of welding in structural work is widely scattered. The following pamphlets have considerable information, especially about tests:

"Arc Welding Structural Steel," published by the General Electric Co., publication GEA-1161.

"Welding Progress in the Structural Field," by W. Spraragen, published by the American Institute of Steel Construction, Inc.

"The Arc Welding of Structural Steel," published by the Westinghouse Electric & Manufacturing Co., publication 1767.

STRUCTURAL-STEEL WELDING DISCUSSED AT MEETING OF CHICAGO ENGINEERS

An informal discussion on design features of structural-steel welding was held by the Western Society of Engineers on Wednesday, January 22nd, in room 1200, Engineers Building, West Wacker Drive, beginning at 7 o'clock. The meeting was presided over by Albert Smith, of the firm of Smith & Brown, engineers, who is chairman of the Structural Section. The attendance of 160, which was more than could be accommodated with seats, was considered to be significant of the interest in structural welding that exists in the Chicago area.

A brief review of welding related to steel structures was read by C. A. Lambert, of the Commonwealth Edison Co. A general discussion was engaged in by J. J. Wallace, of the Joliet Engineering Co., A. L. Wilson, of the Mississippi Valley Structural Steel Co., J. M. Jardine, of the Western Welding & Equipment Co., and others. Representatives from some of the well-known architectural firms in the city also took part in the discussion.

There seemed to be general agreement that the welding of small structures had proved its strength for this kind of work, but some skepticism was apparent when it was suggested that rivets be replaced by welds in large structures, say 20 stories or more in height. Interest was maintained throughout the two hours and a half that the meeting lasted.

Gas Welding Chrome-Nickel Steel

High-Strength Can Be Obtained in This Material by Making Proper Allowance for the Peculiar Characteristics of the Metal

By H. S. Lansing

IN connection with some recent welding operations on aircraft, the writer had occasion to venture into what is to him a new field—that of welding chrome-nickel alloy steel. Obviously, the strength requirements were very exacting; but due to the high strength of the sample materials submitted, the safety factor was sufficiently high so that a 100% joint was by no means necessary. It was necessary, however, to make the joint stronger than ordinary mild steel.

There were no specifications provided for the welding procedure and none of the other welders in the plant had had successful experience with welding this material; so the problem was to take the metal and determine a method which would give the best results and then examine these results to see if they were up to the required standard. The plant executives had been informed that a neighboring firm had failed to get satisfactory results on similar work, so their instructions were to use the greatest care in making a preliminary investigation, and they imposed no restrictions as to time or expense involved.

Although the results obtained were hardly satisfactory, the statements made here regarding the welding of the chrome-nickel steel are not given with the intention of having them taken as a final authority on procedure. They rather represent the conclusions reached upon the basis of the tests conducted. The procedure followed was later compared to procedure in other plants and did not seem to conform exactly to what has been considered to some extent as standard practice. Consequently, any deviations from standard practice will be detailed and their effects noted.

The analysis of the metal used in these tests was:

Chromium	17% to 20%
Nickel	7% to 10%
Silicon	0.5% maximum
Manganese	0.5% maximum
Sulphur	0.025% maximum
Phosphorus	0.025% maximum
Carbon	0.2% maximum

This metal is highly non-corrosive, being unaffected by the atmosphere, salt water, or even a great many of the acids. This is a very desirable quality for aircraft purposes. An equally desirable quality is its non-magnetic feature. In airplanes made of magnetic steel, the compass has to be tested and due allowance made for the effect on the needle of the surrounding metal. Even after this is done, it has been found in some cases that after a short period further corrections are necessary. Therefore, a metal that will not affect the compass is a great factor in simplifying navigation.

Cold-rolled sheets are procurable with as high tensile strength as 150,000 lb. per sq. in., but are too brittle for such purposes, so the standard sheet rated at 90,000 lb. per sq. in. was used. The weight of the standard sheet is the same as steel. Strips of the sheet were cut for filler. No flux was used, though there is a special flux on the market for this class of work. The 0.035-in. pieces were not V'd; the 0.067-in. and 0.125-in. from one side only. As an added check on the thin plate, two welded specimens were tested. The welded pieces were air-cooled, though water quenching is not detrimental to the weld.

In preparing for this test, all three types of flame were used—oxydizing, neutral, and carbonizing. As expected, the oxydizing flame proved very unsatisfactory. The neutral flame gave good results, both as to tensile and bending qualities. But the reducing flame gave slightly higher tensile and, as far as could be determined, equally good bending quality. The bend test was the unscientific and old-fashioned, but efficient and reliable, method of gripping in a vise, hammering to a right angle, and then squeezing the ends together by drawing them up in the vise.

The flame recommended by others for this metal is the neutral, as it is stated that the added carbon will lessen the ductility. But inasmuch as the metal is noted for its excessive ductility, a slight reduction in this quality could take place and still leave it satisfactory in this respect.

The greatest problem in the welding of chrome-nickel steel comes in connection with its expansion, which is approximately 3 times that of steel. And to add to the difficulty, the heat conductivity is less than half that of steel. Here we have a very unusual condition—a melting temperature the same as steel, the heat confined to a small area, and yet a far greater expansion in that area. This makes it necessary to allow much more for contraction, and makes it inadvisable to weld from both sides. And even where these precautions are heeded, internal strain becomes much more of a factor than in steel welds.

Results of Tests of Chrome-Nickel Specimens.

	Thickness of plate	Ult. load, lb. per sq. in.	Yield load, lb. per sq. in.	Elongation in 2 in.
Welded	.067	100,600	70,100	32%
Unwelded	.067	103,200	70,000	48.4%
Welded	.035	91,050	65,000	15%
Welded	.035	88,300	64,900	15%
Unwelded	.035	97,100	71,000	32.5%
Welded	.125	107,500	68,000	35%
Unwelded	.125	116,000	68,500	53.2%

The lower elongation in the welded pieces is natural, due to the reinforcement preventing any elongation in that area.

One other caution is needed—that of keeping the flame continually on the weld. If the flame is suddenly removed, craters or blow holes will form in the pool; thus it is advisable to make the weld continuous.

A summary of the welding method:

Use a small tip; a neutral or, preferably, reducing flame.

Make AMPLE allowance for contraction.

Weld from one side only, with the flame constantly on the melted metal.

Watch pentration closely.

CHICAGO WELDERS LEARN ABOUT CARB-O-FLUX PROCESS

A descriptive lecture on the Carb-O-Flux Arc Welding Process was given by R. W. Holt, Research Engineer, Fusion Welding Corp., at the meeting of the Chicago Section of the American Welding Society held on Feb. 6, at the Greer School, 2026 Wabash Ave., Chicago. Mr. Holt showed samples of sheet metal welded by this process which created considerable interest. He also gave a demonstration, following the lecture, of gas welding an aluminum casting.

COSTS OF ARC-WELDED STEEL BUILDINGS BEING REDUCED

While it has been theoretically possible from the first to construct buildings cheaper by welding than by riveting, imperfect shop methods and other developmental details for some time kept the welding cost higher. General Electric Co. engineers interested in the application of electric arc welding to building construction now point out, however, that the art has progressed to a point to-day where, in many cases, it is actually less expensive to construct by welding than by riveting. As a matter of fact, a number of recent welding bids involving different structures were lower than those covering riveted construction. It should be pointed out in this connection that the cost of welding is not the only factor involved; the use of less steel is an important item; and there are a number of others, including the elimination of noise in building erection in business sections.

The growing number of arc-welded structures is soon to be added to by the erection of a 13-story building for the Southern California Edison Co. in Los Angeles, which is to be almost entirely arc welded, and the building of a 14-story structure for the Boston Edison Co. in Boston, also to be electrically field welded. An application of welding to the construction of city buildings will be made in Schenectady, N. Y., where a new $1,500,000 city hall is to be all-welded.

It is pointed out by the proponents of electric arc welding that these applications represent noteworthy progress towards the general adoption of this new method of building construction. In the building field arc welding has so far had its most extensive application in the construction of factory buildings. The largest structure so far built by this method has been a factory building in West Philadelphia owned by the General Electric Co.

The Boston Edison building will be located at 180-182 Tremont St. and will be the first electrically welded building in the city of Boston. W. A. & H. A. Root are the general contractors; the architects are Bigelow, Wadsworth, Hubbard & Smith; the engineers are The Whidden Beekman Engineering Co.; and Frank P. McKibben will act as consulting engineer for the owners and will be responsible for the welding. This 14-story building will be 60 ft. wide on the front, 112 ft. deep, and 155 ft .high. It will also have a basement and a sub-basement. A total of 1,200 tons of steel will be used in the structure.

The two top floors of the Boston building will be occupied by broadcasting station WEEI, thus giving that station the distinction of being probably the first broadcasting station to be housed in a welded building. Two or three of the lower stories, with the basement, will be occupied by stores.

The Southern California Edison Co. building in Los Angeles will have 13 stories, not including a basement and a pent-house, and will cover a ground space of 180 by 180 ft. and be 150 ft. high. With the exception of the first four stories, all steel work will be electric arc welded. The steel in the first four stories will be partly welded and partly riveted. The architects are Allison & Allison, and the Southern California Edison Co. will act as its own engineer. C. C. Watson of the General Electric Co. will supervise the welding.

An interesting feature of the Los Angeles building is the special design to provide for the contingency of earthquakes. It is said that the building will be built according to the best standards of modern earthquake design. All of this earthquake bracing will be electric arc welded.

EVERYBODY'S BUSINESS

(*Continued from page* 27)

is the fact that the domestic flatirons of the nation now consume more than one billion kilowatt-hours of electricity each year. This is twice as much current as is now used by all of the electric refrigerators, five times as much as is used by the vacuum cleaners and six times as much as is consumed by all of the socket-connected radio sets. From the standpoint of the power companies the flatiron is more important than the electric railroad, for last year the electric irons in American homes used twice as much electricity as was delivered to all of the nation's electrified steam railroads.

Things that appear to be of small importance may become primary factors in the development of a business. If this is true, how essential it is that management shall foresee at the earliest moment the ultimate solution of such major problems as overproduction and the stabilization of gold. With production in many industries largely exceeding domestic demand, how are we going to develop foreign outlets for American goods? Will ours be the dangerous road of imperialism, or the safer one of friendship? A high tariff wall, which appears to be the foundation of high wages, is decidedly detrimental to the expansion of our foreign trade. Without large world markets there will be small hope for the future of the great trusts we are now creating. What are we going to do about all this?

When will we succeed in stabilizing gold? Notwithstanding our rapid progress industrially, mankind has failed to devise a money system different from that which existed thousands of years ago. Trade goes up and down in accordance with the output of the yellow metal. When a nation gets control of the greater part of the gold supply, this fortunate country prospers largely at the expense of other peoples.

The world's most serious economic defect lies in the use of a unit of value, a specific weight of gold, with a widely varying value. In the course of a half century the American gold dollar has exhibited the following gyrations: From 1877 to 1896, it rose 25 per cent; from 1896 to 1920, it fell 70 per cent; from 1920 to September, 1927, it rose 56 per cent. If, figuratively speaking, we say that the yardstick of value was 36 in. long in 1879, when the United States returned to the gold standard, then it was 45 in. long in 1896, 13½ in. long in 1920, and is only about 22 in. long today.

As a result of this instability of currency, property is now taken from one class, without rhyme or reason, and given to another class. And then again, without rhyme or reason, it is taken from the second class and given to a third. This same instability, through inflation, despoils the creditor, the laborer, the endowed institution, the widow and orphan, and enriches the debtor, the business man and the speculator. Later on, through deflation, it enriches the creditor, the endowed institution, the widow and laborer, and robs the active business man and the debtor, including all those who are trying to pay off mortgages on their homes and their farms.

This condition pours forth the poisonous gas of social and political discontent. Within the past few years, the unstable dollar has ruthlessly robbed some and enriched others in the United States to the amount of approximately $40,000,000.

Under existing conditions American business cannot be free of uncertainties. The wisest leader cannot make definite plans for the future without facing the constant threat of a drastic change in our chief unit of value. So long as this situation continues American management will be compelled to take a gambler's chances, based on wild guesses as to whether gold production or commodity prices will go up or down.

There is much unfinished business on hand. We are not through with trade cycles. We have not seen the end of fluctuations that will first exploit one class and then another. Startling discoveries in the field of science will bring wealth to some while entirely upsetting the plans of others. A return to sanity respecting established economic principles, especially the relationship of security prices to earnings, will establish once again the difference between real and unreal wealth—between profits earned by labor and those created on paper by clever manipulation of prices.

We need more minds that are not afraid to go home and think—more people who can spot a fallacy and dissipate an illusion. Not until we recognize clearly the insufficiency of our progress will we cease to be easy fruit for those who offer ready-made opinions to the unthinking herd; who tell people what to think, not how to think; and who strive to develop mass effects, not individual responsibility.

Design of Resistance Welding Machines

Strength of Parts, Method of Applying Pressure, Elimination of Magnetic Losses, Insulation, Are Some of Factors to Be Considered

By Wm. E. Smith†

THE design and construction of welding machines is necessarily a broad subject and is open to much discussion owing to the fact that such rapid progress is being made that in a few years hence our present equipment will be as obsolete as an automobile of the vintage of 1908.

Probably most of us can recall the days when we had to crank our motors by hand, when a set of tires that would run 4000 miles was considered very good, and no car was complete without its share of rattles and squeaks. As we see the latest-model car speeding down the road, making 50 miles per hour without any effort, and the pleasing design as well as the fine appointments that we have become accustomed to, we must remember that this did not all come about by itself; possibly the greatest contributing factor to this progress is research engineering, and that is just what we must apply to welding machines.

Welding has helped considerably to make the present-day automobile what it is and keep the costs low, and is destined to play a bigger part in the production of automobiles, also in all metal industries. Therefore we must design and construct our welding machines to keep pace with this rapid progress.

First, we must keep in mind that a welding machine is a machine tool that must take its place with other machine tools in the shop, producing work accurately and rapidly.

Many of our present welding machines are special machines, each designed to do one particular job only. This is very satisfactory for a factory producing a great many units of a single design, but we must consider the smaller manufacturer whose production would demand the use of a machine only part time for any single operation. Therefore we must make a machine that is interchangeable so that his investment is producing full time.

A very good example of this type of machine is shown in the drawing indicated as Fig. 1, which illustrates a few of the important points in welding-machine design.

When we design a machine tool we figure the strength of material for a part, then give a factor of overload of possibly 3, and if space permits that is increased. But for a welder the factor should be 5 or more, as the machine is subjected to more severe strains than the average machine tool in the shop, which fact becomes evident when we think of the power applied when upsetting the weld. On the machine shown in Fig. 1, the upsetting pressure applied is 8 tons, and this occurs 150 to 200 times per hour.

To maintain accuracy under these conditions, it is necessary to have a large bearing area for the movable platen, which must be kept in alignment with the stationary platen. A good bearing that has proved efficient is also shown. The platen, being made of copper, would not resist the given pressure very long in itself, therefore it is faced with hardened and ground steel plates, $\frac{1}{16}$-in. thick, which furnish an excellent surface and can be fitted close enough to maintain accuracy within 0.005 in.

The bed of the machine is a vital factor for strength, as it must not buckle in the center when upsetting. This should be made of non-ferrous metal to eliminate all magnetic losses.

Aluminum bronze can be used successfully if it has no iron content. If iron is present, heat will be generated, which proves there is a loss of energy. A bronze of 9½-10½ Al, 89½-90½ Cu has been used with good results. However, the highest efficiency has been obtained with pure commercial aluminum; this can be designed with ribs to give sufficient strength, is light in weight, and makes a nice casting, one that is easy to machine; its many advantages overcome its slightly extra cost.

It might be stated that aluminum also was the best metal found for the transformer cage of a spot welder, resulting in increased efficiency.

The transformer is suspended under the bed of the machine as close as practicable to the platen, allowing sufficient space for the free movement of the secondary connection fastened to the movable platen, the secondary connections being made of rolled strip copper, 0.015 in. thick, which insures flexibility. The number of strips and the width should be sufficient to carry the required amperage, and the loop should be inward wherever possible. This will be better understood from Fig. 2, which shows the results of tests made with different loops and lengths of secondaries. Note the increased efficiency where the secondary is short and the loop is close.

The legs of the machine can be made of cast iron high enough to suit the operator.

†*Welding Engineer, The Murray Corporation of America, Detroit, Mich.*

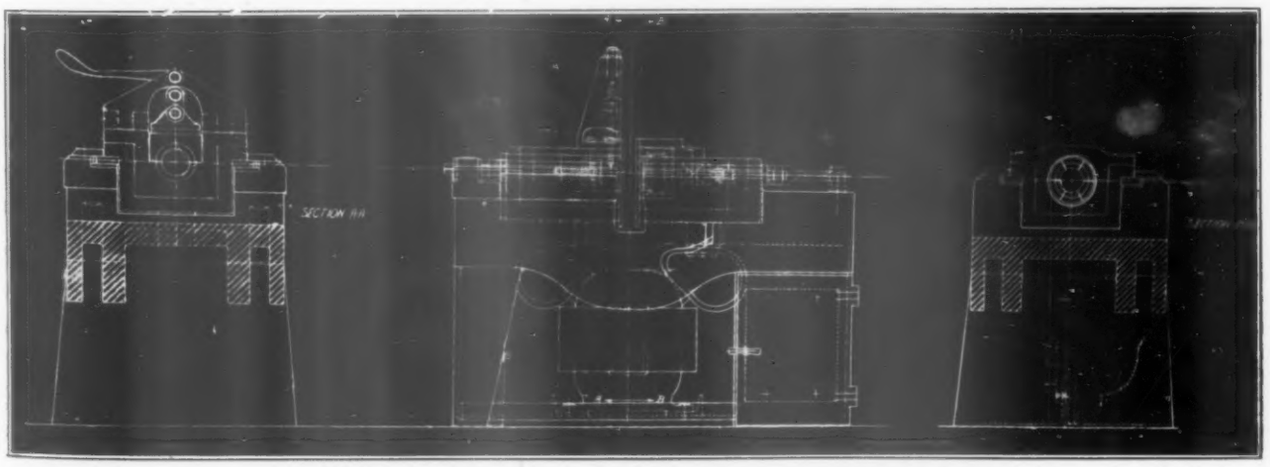


Fig. 1. Working Drawing Illustrating Some of the Important Points in Welding-Machine Design.

Upsetting is obtained by the use of a long lever attached to a plain or compound toggle, the design of the toggle and the length of lever both depending upon the pressure required.

Automatic control is being adopted where it can be used to advantage. As yet it is not as flexible as the lever; and when once made for a certain area of welding it cannot be adjusted to suit a different area, whereas with the toggle and lever plus a good operator many different sizes of work can be done on one machine, within its capacity.

Hydraulic pressure is very successful, the cylinders being placed on the movable platen and pressure supplied by a pump and accumulator. This is very flexible and is used extensively on machines doing heavy work.

Wherever possible, the platens and fixtures that assemble onto the platens should be so designed that the work will be in line with the upsetting toggle. This will give longer life to the bearings as well as maintain accuracy. Though this may seem impossible in many instances at first, it will be found both possible and practicable by applying a little thought.

Insulation is a comparatively simple problem; yet it is the cause of many troubles which are annoying, as a leak due to improper or poor insulation is usually the last thing looked for in the shop.

The stationary platen must be insulated from the frame or bed, as the movable platen is grounded to the bed. The reason for insulating the stationary platen instead of the movable is because of the difficulty of maintaining accuracy with anything less than metal. It is possible to insulate both platens by making the bearing plates of two pieces and separating with mica; however, tests have not shown any increase in efficiency.

Clear sheet mica has proved to be the best insulator because of its dielectric strength and its resistance to heat, moisture, and pressure, although fibre is being used as well as other compositions. The slightly extra cost of mica is soon paid for by keeping the machine on the job and out of the repair shop. All insulation should be made to extend beyond the edges of the metal on all sides, to prevent leaks, which might be caused by metal particles building up and bridging across.

Many sizes and shapes of work can be welded on one machine with the use of proper fixtures. A separate fixture can be used for each particular job; or in many instances it is only necessary to change the dies and stops, the dies or electrodes being made so they can be removed easily for replacement due to natural wear. The fixtures can easily be made interchangeable, as they are fastened to the platen by four or six cap screws and located with keys. The design, of course, must suit the job, and here again extra strength must be figured.

Accurate tests for conductivity show copper to be the best material for fixtures, the comparative figures are given in the accompanying table.

Clamping can be obtained by air, hydraulic, or mechanical pressure. Mechanical means is preferable on average work as it can be made quick acting and economical to operate. However, for heavy work either air or hydraulic pressure is more satisfactory, as it eliminates the long lever necessary to get the required clamping pressure and relieves the operator of any effort other than the opening and closing of a valve.

A welding machine of this type can be used to advantage in either the large or small shop, but should have a special appeal to the small shop because of its ability to handle several different jobs for a low initial outlay. That it will produce quality and quantity has been demonstrated under the most severe conditions.

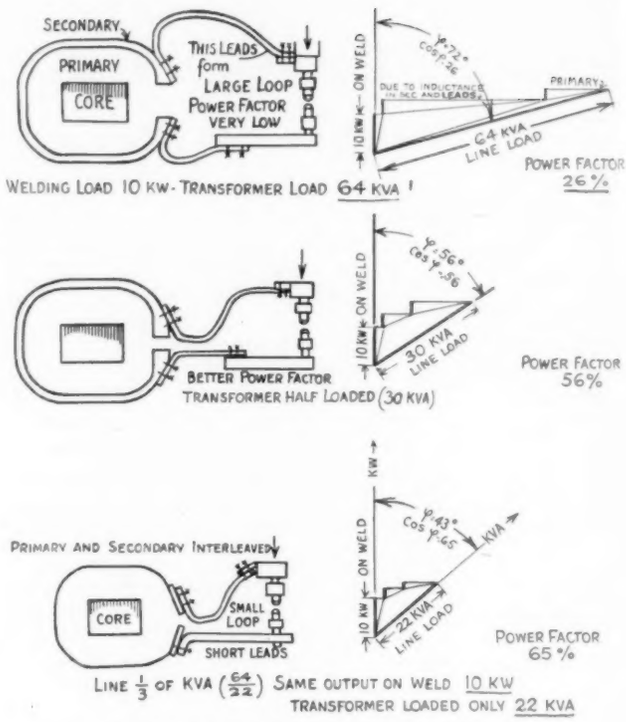


Fig. 2. Results of Tests of Current-Carrying Parts.

Conductivity of Current-Carrying Materials Used in Welding Applications.

Material	Room Temp.	Current Amp.	Drop Millivolts	Resistivity Ohms	Conductivity	Specific Conductivity at 20°C by vol.	by wt.
1. **Lake Copper**	20°C	600	31	0.0000517	58	100%	100%
2. **Cast Copper**	20°C	600	120	0.00020	15	26%	27%
3. **Cast Aluminum** (not pure specimen)	20°C	600	79	0.000131	23	40%	140%
4. **Cast Aluminum Bronze**	37°C	600	260	0.00043	7	14%	
Secondary Coils							
Cast Copper, 330 sq. mm.	27°C	600	54	0.00009	18	31%	34%
Cast Aluminum, 280 sq. mm.	27°C	600	41	0.0000683	26	45%	156%
Copper Cast							
Joint Welded		600	4.5	0.00000750	Cross-section increased		
Solid Copper		600	5.9	0.00000983			
Aluminum Cast							
Joint Welded		600	4.0	0.00000666	Cross-section increased		
Solid Aluminum		600	4.3	0.00000717			

The electrical conductivity of material used in different welding applications for carrying heavy currents, was tested. Specimen bars of cross-section 0.345x1.5=0.5178 sq. in. (334 sq. mm.), and 3.28 ft. (1 meter) long was made from:

Material	Laboratory Analysis Report
Lake Copper	Cu. 99.95%; As. 0.03%—#2579
Cast Copper	Cu. 99.54%; Si. 0.35%; Pb. 0.03%—#2578
Cast Aluminum	Al. 90.81%; Cu. 7.3%. Si. 1.06%; Fe. 0.71%; Mn. 0.08%—#2580
Cast Aluminum Bronze	

Two secondary coils for the welding transformer, same size, were cast from copper and aluminum. Each coil was joined in one place by the torch welding process.

Voltage drop measured at 600 amp., direct current, and resistivity and conductivity calculated.

Lake Copper for conductivity is commercially superior to all other metals.

Cast Copper shows very low conductivity, and is very sensitive to slight changes in chemical and atomic structure. For this reason it is not recommended for electrical purposes, unless special attention is given to casting.

Cast Aluminum. For more complicated conductors, which for technical reasons cannot be made from lake copper, aluminum is recommended. Casting aluminum is less difficult. Conductivity for same cross-sections is 20% to 35% better and is not so sensitive to chemical changes. Castings are more uniform, light in weight, and easy to machine.

The heavy-current-carrying secondaries of the welding transformer must be designed for lower reactance, and stated current carrying capacity is limited by stated temperature rise. Comparative cross-section for cast copper and aluminum is better for cast aluminum. Aluminum being lighter gives more radiating surface and better conductivity for the same weight, a point of great importance in the construction of successful electrical machinery.

Aluminum Bronze is very low in conductivity, being 13% to 20% of lake copper. It is used for welding fixtures where non-magnetic material with great strength is required, and conductivity must be sacrificed.

The Torch Welded Joint on both aluminum and cast copper shows satisfactory results.

A Study of the Flange Pipe Joint

The Flange Type of Weld Is Easily Made "In Position" in the Field and Provides Partial Relief From Stresses Created by Seasonal Heat and Cold

By Lloyd T. Jones[1]

THE rapidity of the development and application of autogenous welding to pipe lines is a quite sufficient reason for one to expect the child to have outgrown his raiment and in the process even to have caused rents to appear now and then.

The inception of pipe-line welding seems to have been with an oil line for the Union Oil Company in Los Angeles in 1908[2]. The various works on welding however generally place the first pipeline welding of consequence to have been that at the Pan Pacific International Exposition at San Francisco in 1915.

The history of the pipe-line girth joint is not known exactly. It is probable that the first welding was for tightness only and consisted in welding around the screw coupling. The second step—the omission of the coupling and the threads—would follow. The natural consequence would be to leave the pipe ends "as is" and make a butt weld, acetylene welding being used almost exclusively at that time.

The preferred welding rod of that period seems to have been pure iron—the purer the better—largely because of lack of experience with steels. Pure iron and low-carbon steel are still used extensively as welding rods when strength is not of primary importance.

Only in pipe lines of more than about 10-in. diameter did serious difficulties begin to appear. Even then it was thought that the difficulties were merely proportional to the diameter, and that they were to be expected in the larger lines. Was it not true that in large riveted pipe lines some of the girth rivets would be sheared now and then and yet the line would be ultimately satisfactorily completed and operated with a 50% girth joint? Did it not therefore follow that a 50% girth weld would be equally satisfactory? It did not, as we now know[4].

At the start of the investigation of stresses in pipe lines a search of the literature failed to reveal a relevant treatise on stresses. The preparation and publication[5] of such a study then became imperative.

The Girth-Welded Mokelumne Pipe Line

The actelyene girth welding of the Mokelumne pipe line may now be considered as a bold advance in welding construction and one which failed[6] in time only. Lack of the few months' time necessary to develop the proper procedure made it necessary to resort to the better-known process of riveting.

Let it be understood that I am still as thoroughly convinced as I was at the close of the study of the girth welding of the Mokelumne pipe line that it is possible to butt weld, (without breakage during either construction or operation) a replica of the Mokelumne line. I shall give in the following pages the reasons why I am also convinced that the butt weld is not the most economical or most suitable girth joint for such a pipe line or for any line of more than a few inches diameter.

As yet no one has produced either a weld metal, or a metal to be welded, which has zero coefficient of expansion with temperature. Until such a metal is produced we shall always have with us the difficulties introduced by the shrinkage of the metal during solidification and cooling, giving rise to the stresses known as residual welding stresses. The difficulties due to the shrinkage of the metal and the consequent residual welding stresses are nowhere more apparent than in the welding of two flat plates, edge to edge.

Fig. 1. The sheet-metal worker makes a standing seam to avoid residual welding stresses in flat sheets.

Fig. 2. Close-up view of a flange girth weld in 24-in. pipe (see Fig. 6).

It has long been the custom to arrange the two flat plates so that they are farther apart at the end opposite the start of the weld and allow the adjacent edges to approach parallelism as the weld progresses. Note that this is merely a method of allowing stresses to be relieved by motion of the parts being welded.

In the welding of flat sheets which are thin, the buckling is more painful, and it has long been customary to form what the sheet-metal worker calls a standing seam (Fig. 1), and weld together the edges thus turned up. Notice that this method relieves the difficulties due to shrinkage of the weld metal by placing that metal *out of the plane of the sheet* so that residual stress can be transmitted to the sheet only through the

[1]Consulting Physicist, Berkeley, California.
[2]I have not yet been able to confirm this.
[4]An unpublished paper "An Intrinsic Property of the Pipe-Line Girth Butt-Weld," soon to appear in Western Gas.
[5]"A Physical Study of the Mokelumne Pipe Line," University of California Press, Berkeley, Calif.
[6]The acetylene welds of the Mokelumne line were reinforced by an internal electric weld and by external straps. Since their completion not one has failed or leaked. Such a line can now be welded without these impedimenta.

flange; and the flange bends rather than to transmit an appreciable stress.

These two facts should be noted:

(1). This weld (of two edges) is one of the easiest and fastest to make. (2) These two flat sheets are but two adjacent plates of a pipe line of infinite diameter.

Let us then at one stroke relieve the pipe-line girth weld of all stress difficulties and at the same time allow the welding to be done much faster and consequently at lower cost by applying the principle involved in the flange weld.

Girth-Joint Characteristics

There are several characteristics—some imperative, some merely desirable—that every girth joint in a pipe line should have:

1. Not a single joint must ever falter during either construction or prolonged use under normal or even extraordinary conditions.

2. There must be no obstruction to flow. A really serious fault of the riveted girth joint is its resistance to flow.

3. The welded joint should, if possible, be made at lower cost than its predecessor—the riveted joint. For this reason I do not look with favor on any type of joint which requires reinforcement in the way of additional straps welded in place.

4. The joint should allow the full strength of the pipe thickness to be utilized in withstanding the operating pressures of the fluid being transported.

5. The Joint should permit a field-construction procedure which simplifies handling of the pipe. The most serious handicap in field procedure at present is the necessity of alining groups for the rolling welds, rolling the pipe, and then moving the group into position.

All of these conditions are successfully met in the flange-welded girth joint shown in Fig. 2 the parent steel of the pipe is flanged outwardly until it is at right angles to the axis of

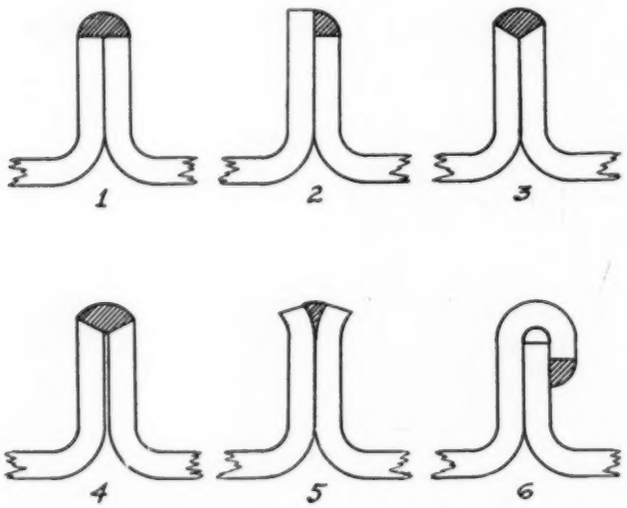


Fig. 3. Many types of flange welds have been made and tested. Types 1 and 2 are equally suitable for acetylene welding. The beveling shown in 3, 4 and 5 is not necessary for usual thicknesses of steel. Type 2 is suitable for electric arc welding.

the pipe. The width of the flange thus formed is normally about four or five times the thickness of the steel of which the pipe is made. The exact dimension of the flanges best suited to a particular project is dependent on the physical conditions to be encountered on that particular project, and a little calculation is therefore necessary.

If the actelyene welding process is to be used in the girth welding, the two flanges are made preferably of equal width (Fig. 3-1) and the peripheries of the two flanges welded together. For steel of less than 3/8-in. thickness no beveling is necessary or desirable. Filler rod is required in all cases except when exceedingly thin pipe is being welded. This type of weld is wonderfully easy (comparatively) to make and the cost will be considerably lower than the cost of a butt weld in the same material.

If the electric-arc system of welding is to be used, the flanges should be of unequal widths (Fig. 3-2), the difference in width being slightly greater than the thickness of the steel. Peculiarly enough, this type of weld also lends itself very nicely to acetylene welding. The cost of acetylene welding of this type is low for the reason that the welder is able to use considerably larger flame than for the weld shown in Fig. 3-1.

Each of the types shown in Fig. 3 has been used in test work.

The types of girth joints that have hitherto been used employ

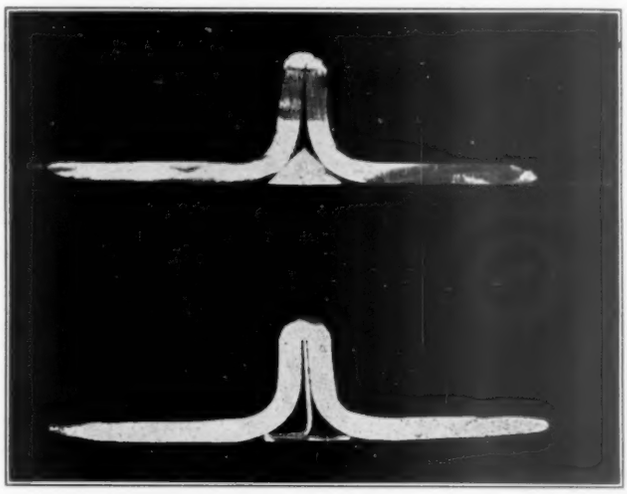


Fig. 4. The inserted fillets will produce a smooth interior if such be desired.

quite different and distinct methods of meeting the stresses encountered during the construction and service.

For example, the butt weld provides no motion in relief of stress and therefore must possess a strength equal[4] to that of the steel of which the pipe is made. It may be stated in a slightly different manner by saying that the butt weld must provide 100% axial strength, since it cannot move in relief of stress and since at least one portion of the weld is under a tension equal to the elastic limit of the metal.

Some of the mechanical joints operate in a manner indentical with that of the usual slip expansion joint. These possess no axial strength whatever, yet nevertheless are perfectly satisfactory as joints insofar as axial stresses are concerned. Possessing zero axial strength, they present the alternative—motion in relief of stress. Motion is a perfectly satisfactory method of relieving axial pipe-line stresses.

The other advantage of the slip expansion joint lies in the opportunity it gives one to build cement houses around the joints and the continual employment it affords in keeping the glands packed.

A few certain types of mechanical joint possess some axial strength and allow some motion in relief of stress. Since no new basic principle is involved, they will not be discussed in detail.

The Flange Girth Weld

The mode of operation of the flange weld is a combination of the two cases previously cited. It presents a welded joint that is entirely free from leakage, low in first cost, requires no maintenance, has no residual stresses with which to contend, and possesses sufficient axial strength to cause the flanges to move in relief of any stresses, accidental or otherwise, that may be impressed. Let it be noted that the only axial strength necessary is that required to cause the flanges to function.

I cannot emphasize too strongly that the flange weld has four exceedingly desirable properties.

1. It has zero residual welding stress.

2. Should the line be accidentally subjected to an enormous stress the flanges can move permanently an amount sufficient to relieve a stress greater than the elastic limit of the steel of the pipe.

3. After the line is buried and regardless of the constructional stresses introduced in the process of laying, the flanges will need move an amount only sufficient to relieve the stress due to seasonal temperature changes. This seasonal temperature change is known and the flanges are made of such

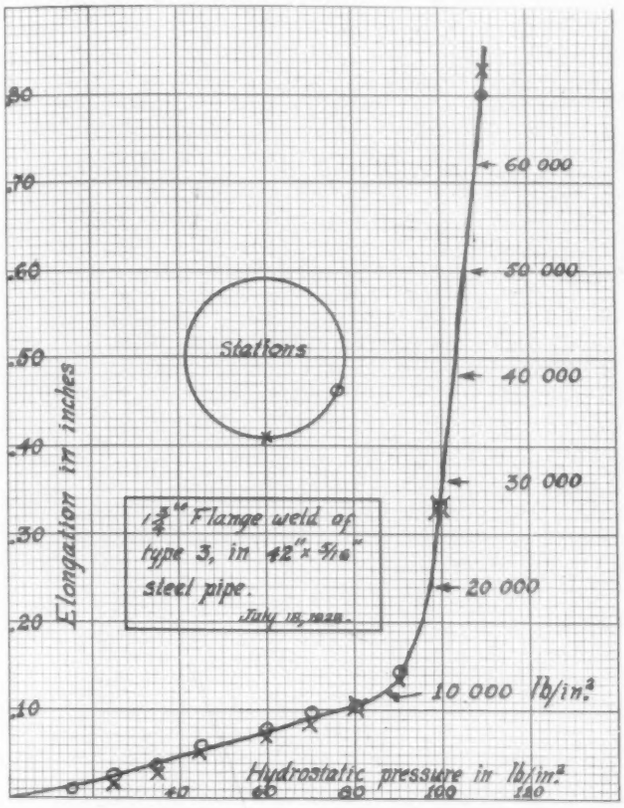


Fig. 5. The relief of stresses by providing motion in pipe-line welded joints is a recent development. The shape of this curve is dependent on the pipe and flange dimensions, which in turn are calculated from the known conditions the pipe line is to encounter.

width that the corresponding motion lies entirely within the elastic limit of the flanges. They are thus able successfully to pass through an indefinitely large number of seasonal changes.

4. The interior is smooth. If a pipe line conveys either water or gas at a rate of flow so slow that nonturbulent flow exists, and it is desirable for the joints to have a perfectly smooth interior, such can be provided by the means shown in Fig. 4. In the upper view the "piston-ring" fillet is placed in position after the joint has been completed and the interior of the pipe given its protecting coating. The painting of the fillet will then leave a noticeably smooth interior.

It is very doubtful whether it is ever necessary to make a smooth interior for pipe lines transporting gas. It can be accomplished however by inserting a fillet as shown in the lower view in Fig. 4, the fillet being welded into place as the joint is welded. The welding of the joint is not affected by the presence of the fillet.

Relation Between Elongation and Stress

A single example may suffice to exhibit the characteristics of the flange-welded girth joint and its method of extending longitudinally to relieve stress. The curve in Fig. 5 shows the relation between axial elongation of the flange-welded girth joint of a 42x$\frac{5}{16}$-in. steel pipe and the axial stress. The hydrostatic pressure, plotted along the horizontal axis refers to the pressure in the closed vessel used to produce the axial stress. The values in pounds per square inch, indicated at points along the curve itself, are actual values of the equivalent axial stress in the steel computed from the hydrostatic pressure and the elongation.

Notice that for elongations less than 0.10 in. (10,000 lb. per sq. in. stress), the curve is a straight line. This shows that Hooke's law is obeyed and the elastic limit of the metal has not been exceeded. It is worth while in passing to state that the stress of 10,000 lb. per sq. in. is equivalent to a temperature change of 50 deg. F. Buried pipe lines do not often change in temperature so markedly as this, and this particular width of flange may therefore be considered satisfactory for lines which undergo no more severe condition than that.

On the Mokelumne pipe line the largest stress measured was 12,000 lb. per sq. in. This occurred during construction and when the temperature of the pipe ran up to 160 deg. F. The seasonal stress variations are very small.

Many are familiar with the method of judging the action of the whole pipe line from a consideration of the action of a single joint under test. The test shows this joint to be eminently satisfactory.

If more abundant evidence of the success of the joint be necessary, I shall refer to the 24-in. line constructed for the East Bay Municipal Utility District[7]. Fig. 6 shows the completed line crossing the Jackson Creek spillway at the upper end of the Mokelumne reservoir. The line is supported on piers placed at 30-ft. intervals. The flange-welded pipe has to carry the three tons of water in each pipe section and at the same time provide movement for the extreme changes in temperature met on this line. During a portion of the summer the line lies empty and exposed to the sun. At night the temperature falls nearly to the freezing point.

During a considerable portion of time the daily temperature range of this pipe is greater than the annual temperature variation in a buried line. From this point of view we may then state that the line has already undergone two hundred

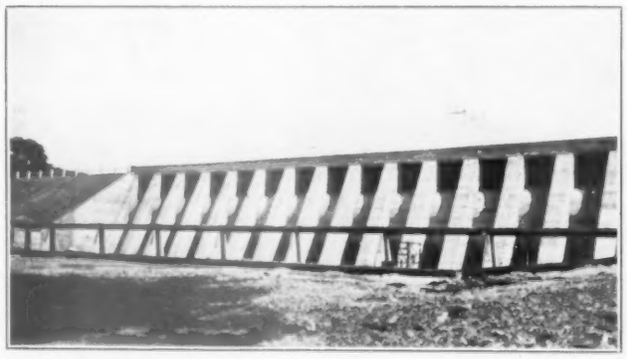


Fig. 6. This 24-in. flange-welded line is supported on piers and carries three tons of water in each inter-pier portion. The welds provide sufficient motion to relieve the stresses due to summer sun and winter cold.

temperature cycles each of which corresponds to the usual annual cycle.

The flange weld is best suited to be a girth joint in a buried pipe line. The supreme test which it has undergone in this its first installation, wherein it has provided movement in response to as many temperature cycles as would be encountered in two hundred years of life as a buried line, is ample verification of my belief that it is entirely suited for the work that lies before it.

Field Construction

Perhaps the most important features of the flange weld are its reduction in welding cost to approximately half that of the butt weld and the simultaneous simplification in pipe handling that it introduces.

The weld is so much simpler to make that every weld is

[7]Jour. Amer. Water Works Assoc., 21, p. 1153, 1929.

by desire a "position weld," the pipe being neither rotated nor moved. As a consequence pipe sections may be assembled immediately above the ditch, end to end, without limit as to length. Since the flanges are placed in contact, the work of one welder will not cause motion[8] of the pipe and will therefore not interefere with the work of any other welder.

We can eliminate most of the crew employed for aligning and tacking the pipe in groups, rolling the group, and moving the group into position above the ditch. The welding and laying is therefore reduced to a strictly continuous-process production method.

The Flange Weld and Gas Transportation

A few months ago I published the equations[9] describing the effect of the tapered pipe line on the economical transportation of gas. It was there shown that the tapered pipe line would transport 60% more gas per ton of steel than the cylindrical line, and the cost of construction would be no greater. It may be stated in a different manner by saying that the tapered line will transmit as much gas per ton of pipe as the same cylindrical pipe tonnage *plus* the usual number of compressor stations. The daily delivery of the tapered line is given by the following equation:

$$Q_s = 8.0507 \times 10^6 \left[\frac{k(P_1^2 - P_2^2) d_1^{4\frac{1}{3}} d_2^{4\frac{1}{3}}}{G\,T(d_2^{4\frac{1}{3}} - d_1^{4\frac{1}{3}})} \right]^{\frac{1}{2}}$$

Where

P_1 = initial pressure in lb. per sq. in. abs.
P_2 = final pressure in lb. per sq. in. abs.
d_1 = initial diameter in in.
d_2 = final diameter in in.
k = ratio increase in diameter to length, in any consistent units.
G = specific gravity of gas relative to air.
T = flow temperature in deg. F. abs.
Q_s = cubic feet daily at 60 deg. F. and atmos. pressure.

The length of the pipe line does not appear in the equation of the tapered line, but it is involved in the value of k.

The calculations previously published related to a 250-mile line of 20-in. diameter. The present calculations will concern a very long and very large-diameter line. It will then be seen that the principle of the tapered pipe line for gas is applicable in either case[10].

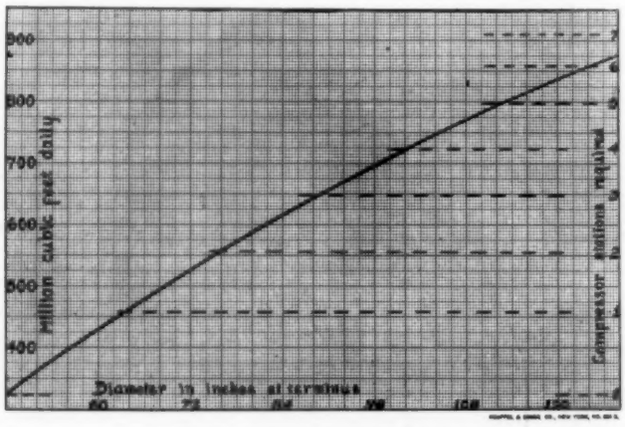


Fig. 7. The curve shows the quantity of gas that can be transported by a 1,000-mile tapered pipe line having an initial diameter of 48 in., with the final diameter shown as abscissae. The horizontal dotted lines indicate the number of intermediate compressor stations that would be required to produce equal flow in a 48-in. cylindrical line. Both lines use equal amounts of steel and are equal in cost of construction (without compressor stations in the cylindrical line).

Suppose it is desired to transport 300,000,000 cu. ft. daily a distance of 1,000 miles, with the expectation that the amount may need be increased as the market develops. Assume initial and final pressures of 400 and 100 lb. per sq. in., respectively[11].

A 48-in. cylindrical line of ¾-in. steel will transport 325,000,000 cu. ft. daily. The insertion of one, two, or more intermediate compressor stations would augment the flow to the values indicated by the horizontal dotted lines in Fig. 7. The number of compressor stations is shown at the right, and the quantity transported indicated at the left. This curve shows the relation between the final diameter of the pipe in inches and the flow in millions of cubic feet daily in a tapered line, the initial diameter of the pipe in all cases being 48 in.

Previous publications on the tapered line have pointed out that the thickness of the steel is decreased as the diameter of the pipe increases, the steel tonnage thus remaining equal to that of the cylindrical line.

Flange Welds Hold Down Cost of Tapered Lines

The method of girth welding just described is applicable to a pipe line of the size considered above. By utilizing that method the cost of welding would be independent of the diameter of the pipe and therefore the same as for the cylindrical line.

Tapering the line is thus seen to apply equally well to the largest and longest pipe lines likely to be used in transporting gas.

The value of the flange weld in gas transportation may be readily translated into dollars by estimating the cost of the equivalent compressor stations, being careful to add in the cost of operation, maintenance, depreciation and interest on the investment.

LARGE PIPE LINE EMPLOYS BOTH WELDED AND RIVETED JOINTS

Water mains of 54 and 66 in. diameter, being laid for the city of Detroit, have several novel features in design which are described by Russell C. Beam in the ffourth issue, 1929, of *The Pure Iron Era,* published by The Armco International Corp.

The pipe was fabricated in the shop, being built in four sections of ½-in. Armco-iron plate. The circular seams were lapped approximately 1½ in. and were welded inside and out, while the longitudinal seam in each of the four sections was butt welded, making a 40-ft. length of pipe. Taper rings were used throughout, and the field joints were also designed to use tapered sections. The field joints were riveted.

As these lengths of pipe were 25% longer than standard, the number of field joints were reduced proportionately. In the 9,300 ft. of 54-in. pipe, only 233 joints had to be riveted, instead of 310. This is the first time this design has been used on a large welded transmission pipe line. Foremost among the advantages accruing from the combination of old design and its new application are a pipe that is unusually stiff, because of the lap-welded girth joints and the inclusion of only one longitudinal joint instead of two, and a pipe that can be placed under deeper fills without angle-iron reinforcing rings. Reinforcing rings are being employed on the 54-in. line; but will be dispensed with on the 66-in. line, which is to be laid under city streets.

These 40-ft. lengths of pipe were coated with a hot bitumatic solution by dipping them in a deep well filled with Hermastic enamel, which was dug through the floor of the factory building and into which was fitted a tank filled with Hermastic enamel.

This same issue of *The Pure Iron Era* contains a descriptive article on the all-welded steel barge launched at the plant of the Electric Boat Co. of Groton, Conn., on October 26th, which has been mentioned in past issues of *The Welding Engineer.*

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[8] In welding the 42x⅜-in. joint of Fig. 5, no tacks were used. The joint was held by only three C-clamps.
[9] Western Gas, May 1929; Oil and Gas Journal, May 1929.
[10] There are many objections to a single large line. There are more points in its favor, however.
[11] The one best location for a compressor station is at the source of gas, where natural high pressures exist, and I do not therefore believe that 400 lb. will always remain a suitable initial pressure.

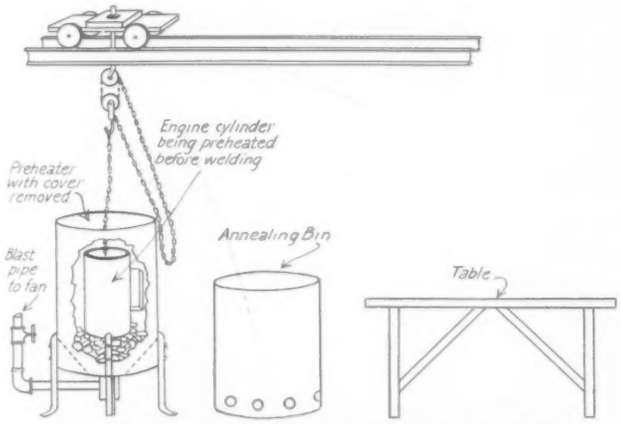
Hints for the Welder

WHEN YOU FIND a new way to do a hard job, or finish a particularly interesting weld, can you describe how the work was done? . . . . . Have you learned some little stunt every welder ought to know? . . . . . Write to us about these things . . . . . This department helps you welders to help each other. Write up your ideas any old way and just make rough pencil sketches . . . . We'll fix them up for publication.

WELDING HEAVY CASTINGS

By R. C. Leibe

The general welding shop must be prepared to handle almost any class of work from a stove-lid lifter and automobile keys up to large steam-engine cylinders. Each welding job presents a different problem. On going into the welding business, our equipment consisted of the usual devices obtainable on the market. But we soon found that something different had to be designed and made to meet the conditions demanded for satisfactory work. Every time a large casting came in, much valuable time was consumed in preparing a special preheating furnace to handle that particular job, owing to the casting's size or shape. Often several such large



Layout of Equipment for Handling Castings to Be Welded.

castings came in for quick welding at one time. This condition was met in a unique manner, which has proved a great boon in time saving, quicker handling of many jobs, and no failures in welding from improper preheating and annealing, which are the greatest difficulties encountered in large castings, owing to expansion and shrinkage of cast iron.

First, we secured several joints of an old smoke stack at a machine shop. These were about 30 in. in diameter and 4 ft. in height. From these we formed three preheating furnaces and three annealing bins. Each such joint used for a preheating furnace was mounted on four iron legs, as seen in the illustration. A sloping bottom was installed of a like material, with an opening at the bottom to resemble a funnel. A common pipe tee was welded into the lower part of this funnel and piping screwed into the side opening of the tee, the pipe leading to a little motor-driven fan. The preheater has a steel-plate cover. The three preheaters so constructed were located in a line, with air piping from the fan connected to each and pipe valves in the line between each unit for adjustment to obtain the needed amount of forced draft or to cut any one of the furnaces out when not in use.

Located by each preheating furnace was an annealing bin made of the same size of smoke-stack joint as the preheating furnace, but resting directly on the ground floor of the shop. This annealing bin contained holes around the bottom for slow ventilation. The charcoal within could be kept alive for a time by closing these holes with a slip iron band, and the casting within would come to a slow cooling.

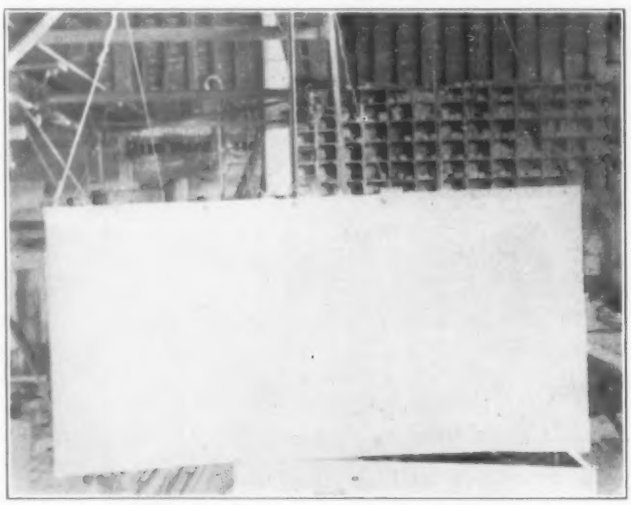
To handle the heavy castings, which were mainly steam and large gasoline engine cylinders, an overhead trolley was used with lightweight railroad rails for tracking, swung from overhead joists. To the trolley was fastened a small chain-falls or lift. A welding table, in line with the other units and with the tracking, is used for such welding that cannot be handled directly over the preheating furnaces by the trolley chain. The trolley serves the furnaces, annealing bins, and also the tables.

With this unique and handy outfit, the welding of heavy castings is facilitated, and work can be handled easily and quickly when hot and transferred from any one of the preheating furnaces to a welding table and back to an annealing bin without loss of much heat, which is the secret of good work on circular castings. Charcoal is used with fine coke for firing the preheaters. A casting is preheated, then welded on the welding table, then returned to the preheater for a few minutes, and then brought to the annealing bin, containing a slow fire of charcoal, and the draft is cut off at the bottom holes for slow cooling when the lid is put on.

CANVAS BOOTH FOR THE WELDER

By J. C. Coyle

For the small shop where space is at a premium, a canvas welding booth will be of great advantage. In one shop, the canvas is sewed upon a frame of light ¾-in. pipe, and is suspended from



Welder's Booth Suspended From Ceiling.

a pulley at the ceiling by means of small wire ropes leading to each corner of the frame, so that when not in use it may be pushed upward out of the way to admit of the placing or moving of material. A weight holds the booth in place when in use.

THE CONTROL OF EXPANSION AND CONTRACTION IN TANK WELDING

By B. Bird

Considerable skill is required to weld longitudinal seams, especially seams of pressure containers. The welder must secure thorough penetration and fusion and at the same time watch the seam so that contraction proceeds evenly.

If the welding is properly executed and the contraction neglected, the tank or cylindrical shell will be "out of round" in some places and a poor-looking job in general.

Welders with experience in tank welding have usually adopted methods of their own to handle the problem of expansion and contraction. Wedges, pinch-bars, clamps, etc., are frequently

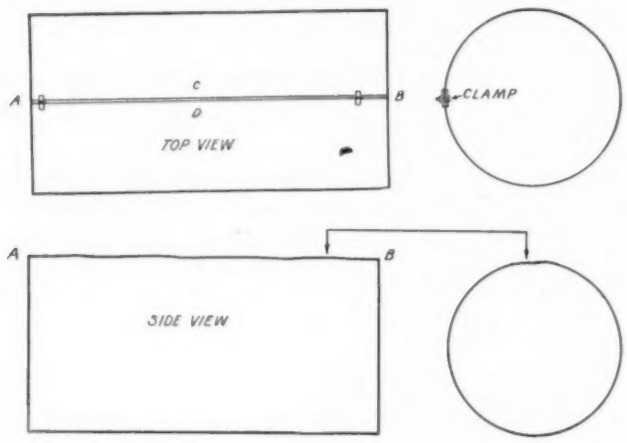


Fig. 1 Above, Fig. 2 Below. Irregularities in Line AB in Fig. 2 Are Caused by Improper Method of Controlling the Contraction Strains.

used. In cases of long seams the welder has a helper who aids in keeping the seam straight and who also watches the contraction so that the seam will come together properly.

To those welders who have had little or no experience in tank welding, the following may be of some value: Assume that you are about to weld the longitudinal seam of a cylindrical shell or tank. The plate is ⅜ in. thick and is properly beveled and rolled to size. Assume the tank to be 8 ft. long and 4 ft. in diameter. If an attempt is made to weld the longitudinal seam *A B*, shown

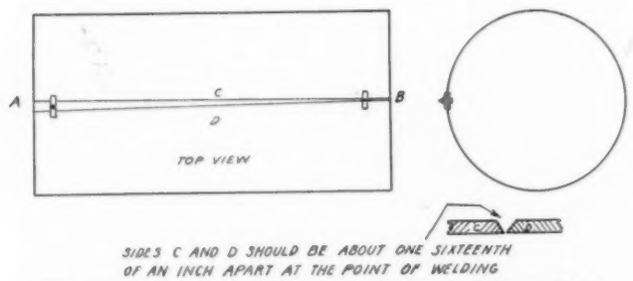


Fig. 3. Illustrating Proper Layout Before Starting to Weld.

in Fig. 1, with edges *C* and *D* parallel, a great deal of difficulty will be encountered, because the contraction strains would cause the cylinder to warp and possibly overlap. The finished seam would appear as in Fig. 2.

In order to weld the seam successfully, one end of the seam must be opened to make proper allowance for contraction. In oxy-acetylene welding the opening should be ½ in. for every foot of the length of the seam. In electric arc welding the opening should be ¼ in. for every foot of the length of the seam. We will assume that the tank will be gas filled, so the opening at the end will be $8 \times \frac{1}{2} = 4$ in. The opening at the starting point should be about $\frac{1}{16}$ in.

Start welding at end *B* and proceed as rapidly as possible, taking pains to see that you are obtaining thorough fusion and penetration. Also see that the sides *C* and *D* are "flush" at all times; this can be accomplished by inserting a pinch-bar in the seam about 2 ft. ahead of the weld. It is best to complete the weld in one "heat" if possible. As the welding progresses the seam will start closing, and the clamp at end *A* should be gradually released so that the seam will come together properly. The contraction should be handled so as to keep sides *C* and *D* about $\frac{1}{16}$ in. apart at all times (see Fig. 3).

Occasionally the welder may fail to adjust the seam properly,

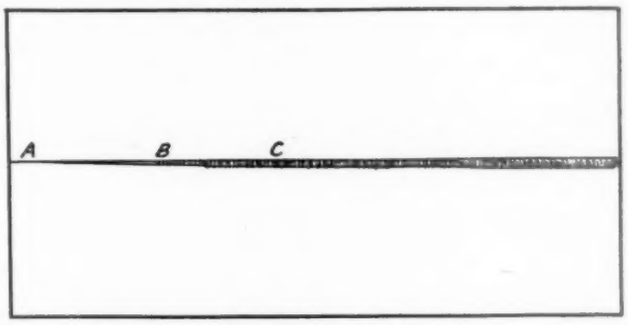


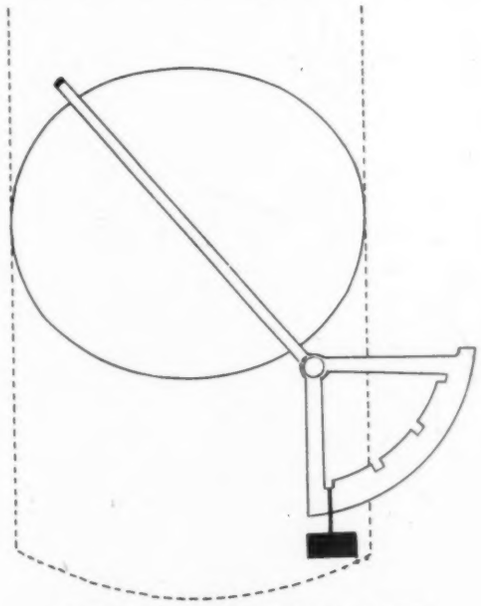
Fig. 4. If Seam Laps at A When Welding Reaches B, Play Torch From C to B, Heating the Weld to Cherry Red, and Seam Will Open at A. The Seam Should Then Be Tacked.

and the sides *C* and *D* overlap. A study of Fig. 4 will show how to reopen the seam.

Before attempting to weld any long seams on heavy plate it would be well worth the beginner's time to get a piece of 10-in. pipe, make one longitudinal cut on the pipe with the oxy-acetylene torch, then proceed to weld as though he were welding the seam in a tank. He will be surprised to see the effect the heat has on the metal. A little experimental work done in this way will prove to be very valuable.

A WELDED STACK DAMPER

A welder who was called on to make a damper for a smoke stack turned out a very neat and serviceable job following the design indicated in the accompanying sketch. The damper itself was readily made by cutting a circular disc of scrap plate.

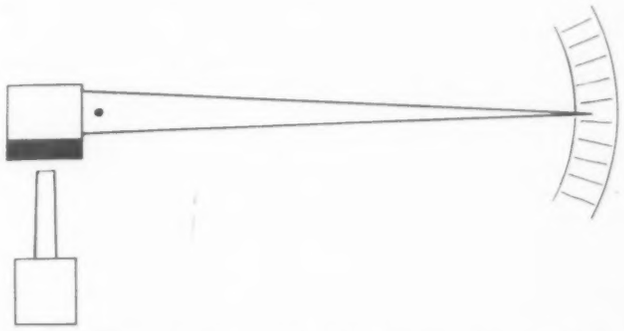


Smoke-Stack Damper Made by Welding.

This is held on a rod by fasteners welded to the plate. At the end of the rod is welded a quadrant cut from quarter-inch plate and notched in four places, as shown. A loop of welding wire welded to a heavy piece of scrap iron forms the weight. By shifting this weight from one notch to another it is possible to hold the damper in any one of four positions of adjustment.

STELLITE SAVES INDICATOR

In a piece of testing apparatus readings were taken from a pointer swinging on a circular dial. The pointer carried a rather heavy counterweight on the other end, and this was put in motion by sharp blows from a steel plunger directly beneath it. When this was in operation it was found that the plunger gradually wore a hole in the counterweight, which in a short time rendered the whole recording apparatus inaccurate. To cure this condition a small deposit of Stellite was made on the wearing surface. The total deposit of Stellite is only about a half inch square and less than an eighth of an inch in thickness, but since it has been applied there has been no further need for replacement. The plunger has a tendency to mushroom slightly; this also was treated with Stellite to keep it from wearing, but the action of the pointer caused by the contact of two extremely hard surfaces was too violent, so the Stellite was removed from the plunger.



Stellite Deposit on Pointer Counterweight Withstands Blows of Plunger.

STEEL MEN HONOR SPERRY FOR PAPER ON NEW TEST METHOD

The first award of the American Iron & Steel Institute medal has been made to Elmer A. Sperry, president of the Sperry Gyroscope Co., for a paper of his describing a method he developed for detecting flaws in steel rails, which he later applied to the testing of welds in bars, plates, and rods. Although the award was announced last October while Dr. Sperry was in Tokio attending the World Engineering Congress, formal presentation of the medal was just recently made by Charles M. Schwab, chairman of the board of the Bethlehem Steel Corp., and president of the Institute.

IOWA AIRCRAFT WELDING SCHOOL

Information concerning the future demands for aircraft welders, pay for welders, opportunities for advancement in this field, equipment and teaching staff of the Iowa Aircraft Welding School, tuition, and living expenses in Des Moines, is given in question-and-answer form in a folder recently issued by the Iowa Aircraft Welding School, 610 University Ave., Des Moines, Iowa. Two typical views of welding classes at work are shown. This folder states that the estimated requirements for new planes in 1930 will create a demand for 15,000 experienced welders.

The day course given by this school consists of 150 hr. over a period of 5 weeks, and the night course consists of 150 hr. spread over 12 weeks. Oxy-acetylene welding alone is taught. A special short course of 100 hr. can also be had.

JOURNEYMEN PLUMBERS LEARN WELDING

The Chicago Journeymen Plumbers Association is holding welding classes at 1340 Washington Blvd. on Monday, Wednesday and Thursday nights of each week to teach apprentices and journeymen the first principles of oxy-acetylene welding and the application of welding to piping layouts and repairs. Each class is conducted for a period of two hours. This school has now been in progress for more than a year.

At present about 60 are enrolled. Each student attends one night a week for ten weeks, or one semester. The second semester also consists of ten weeks. The charge for each student—$1 per night—is not sufficient to cover the expenses of the school, the balance of the cost being borne by the Association itself.

A school in lead burning is also conducted in connection with the welding school. Mr. J. J. Roche is in charge of welding and Mr. Tuttle in charge of lead burning.

Class in Welding Conducted for Benefit of Chicago Plumbers.

The benefits of welding were forcibly impressed on the journeymen plumbers by an instance where a branch connection was welded to a riser with a saving in labor alone of $174. Now the plumbers are learning how to weld in connections, joint pipes, and make repairs by cutting and welding, it being realized that welding will be demanded in many cases for this kind of work.

REGO GAS ECONOMIZER

The Bastian-Blessing Co., 258 East Ontario St., Chicago, have recently placed on the market a gas economizer which has several innovations for this type of apparatus. The shut-off valves of the Rego economizer are of the diaphragm type, for which it is claimed that no leaks can develop. Arms, body and diaphragm bonnets are of forged brass, adding further to the leak-proof features of the unit. To eliminate the possibility of the pilot light becoming clogged with soot or permitting soot to float about in the air, a lava tip is provided which the manufacturers state, draws in sufficient air and mixes it with the acetylene before ignition so that complete combustion of the gas results. The unit is compact in size and can be easily installed in the shop close to the welding operation. A bracket for installing the economizer is available on which the torch tips can be kept.

New Gas Economizer

MACHINE ARC WELDS WIRE WHEELS AUTOMATICALLY

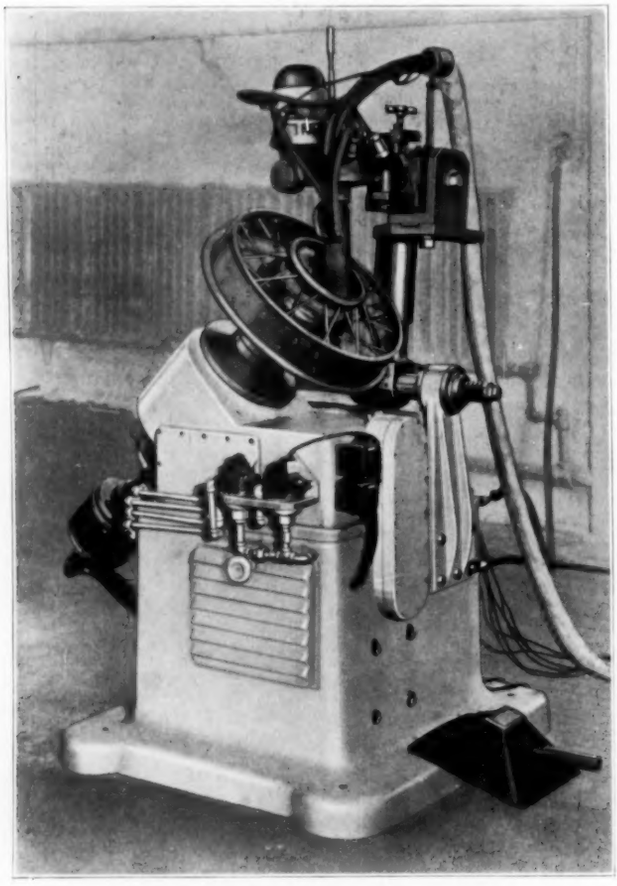
An automatic machine for the manufacture of wire wheels, by carbon arc welding process, as shown in the accompanying illustration, has recently been introduced into the automotive industry.

The purpose of this machine is to make a lap weld to join

the pressed steel parts inside the hub as the wheel turns in a jig. The welding time for an 8-in. hub, as shown in the illustration, is 40 seconds, and the floor to floor production of this size wheel is 50 per hour.

The application of the arc welding process in this machine is very interesting. It embodies the features of the Electronic Tornado, manufactured by The Lincoln Electric Company, Cleveland, Ohio, which utilizes the carbon arc welding process. No metal filler rod is necessary. The metals of the hub are fused together as they rotate in the jig.

In joining the pressed steel parts of a wire wheel, it is claimed that the carbon arc welding process makes it possible to secure the strength and rigidity that might be had



Automatic Arc Welder for Wire Wheels.

by forming all these parts as an integral piece of steel. The smooth well-rounded bead gives the hub of this wheel the appearance of a homogenous steel unit, and the welds are comparable to the finest steel.

NEW BOOK ON GAS WELDING AND CUTTING

"Oxy-Acetylene Welding and Cutting," by Stuart Plumley; 302 pages, 7¾x11 in.; 435 illustrations. Cloth binding; price, $7.50. Published by the University Printing Co., 315 Fourteenth Ave. S.E., Minneapolis, Minn.

This is a textbook written in a series of twenty lessons covering all classes of welding. A job sheet follows each lesson to give the student a specific job to be done after he has mastered the lesson. In this manner he can gain the necessary skill in handling the torch and make a practical application of the knowledge gained from the lesson. At the end of each job sheet is a series of questions which, when correctly answered by the student, will prove his knowledge of the lesson and help to fix in his mind the main points of the lesson.

The author, Stuart Plumley, is a well-known figure in the welding field, having been actively identified with the oxy-acetylene industry for more than twenty years. Most of the jobs illustrated and described in this book have actually been done by him and his assistants to establish the practices set forth.

Schools, manufacturing plants, welding shops, and other places where the oxy-acetylene torch is used, will find this book of great value. The subjects covered by the lessons are, in the order given in the book, as follows: Setting up the equipment; welding torches and regulators; welding sheet steel, with instructions on gases and cylinders; vertical welding of sheet metal, and cutting; acetylene generators and shop pipe lines; welding and cutting small-diameter pipe; use of templets; welding large-diameter pipe lines; miscellaneous welding jobs in steel; welding tanks; miscellaneous jobs about a job shop; applications of welding to steel; welding and cutting in the steel foundry; bronze welding cast iron, malleable iron, and steel; the business side of welding; fusion welding of cast iron; cutting cast iron; brazing and silver soldering; welding aluminum, monel metal, nickel, copper, and various alloys; lead burning; building up battery terminals; soldering automobile radiators; jobs for the job shop; airplane welding. An index is included.

NEW BOOKLET ON OXWELDED PIPING

The history of oxy-acetylene welded pipe and actual applications of the welding process to pipe joints and to pipe repairs, are reviewed in a 77-page booklet issued by The Linde Air Products Co., 30 East 42nd St., New York, N. Y. Welded pipe is compared from the standpoint of construction and design with flanged pipe. Procedure control methods, by which proper and uniform welds are assured, are outlined.

Examples are related of the successful use of welded pipe for overland lines carrying oil and gas, in which emphasis is laid on the lower cost of welded installations compared with flanged pipe. Information is given on installations of welded pipe for the carrying of steam and hot water at high pressures and for industrial and process piping, and cases are cited where welded piping has reduced installation costs and maintenance expenses in buildings and residences. A chapter on refrigeration piping indicates some of the severe tests that welded piping undergoes in the ice-plant and refrigeration field.

Many interesting illustrations are shown to give some idea of the flexibility of welded piping and its service to different industries.

CARBIDE LIGHTS FEATURED IN BOOKLET

A descriptive booklet on National Carbide lights, including the V G Light, the V G Handy Light, and lanterns, was recently published by the National Carbide Sales Corp., 342 Madison Ave., New York, N. Y. Illustrations suggest some of the many fields for use of these lights, which are designed to promote the use of carbide. Several of the photographs reproduced were taken in dark subways by the aid of V G Lights alone. Emphasis is placed on the dependability and long life of these lights.

BOOKLET ON ARC WELDING OF CAST IRON

A recent publication of the Westinghouse Electric & Manufacturing Co. is Arc Welding Data No. 11 on "The Arc Welding of Cast Iron." This bulletin points out some of the properties of cast iron and gives a recommended procedure to be followed in arc welding.

Illustrations show the characteristics of cast iron which influences its weldability, the characteristics obtained by both the carbon and the metallic arc processes, the general procedure recommended for doing metallic arc welding on cast-iron parts, and several interesting views of cast-iron machinery parts which have been repaired by arc welding.

Since the economy behind the application of arc welding to the repair or reclamation of cast-iron machinery or parts is widely recognized, the information presented in this publication is of particular interest to users of such equipment.

THOMSON-GIBB ISSUES LEAFLET ON SEAM WELDING

A small heavy-duty air-operated seam welder, known as the No. 324 HDA, is described in a recent bulletin of the Thomson-Gibb Electric Welding Co., Bay City, Mich. This machine is said to be especially adapted for rapid straight or circular seaming of the lighter gages of stock. The sturdy construction of the tool is described, and a table gives dimensions, rating, seaming capacities, and weight. The reverse side of the leaflet is devoted to a general description of the Thomson-Gibb seam welding process.

FOLDER ON PORTABLE ARC WELDERS

The Hobart "Constant Arc" Welder is illustrated and described in a folder recently issued by Hobart Brothers, Troy, Ohio. Emphasis is laid on the extreme simplicity of operation and control that can be obtained with this welder. Equipment includes the "Unitrol" Dial, which gives centralized and simplified control. It is pointed out that cut-and-try methods of adjustment are eliminated by this type of welder. The advantages of welding in production and maintenance work are brought out.

GENERAL SPECIFICATIONS FOR STRUCTURAL ARC WELDING

A leaflet giving general specifications for the arc welding of structural steel has been issued by The Lincoln Electric Co., Department No. 27-1, Cleveland, Ohio. This leaflet, specially prepared for architects and engineers, touches upon such topics as drawings, dimensions and strengths of welds, welding equipment, personnel, and execution of the work, and also contains the A.I.A. file number for convenience in indexing.

G-E GAS-ENGINE-DRIVEN ARC WELDERS DESCRIBED IN NEW BULLETINS

Portable arc welding sets driven by gas engines are the subjects of two bulletins recently issued by the General Electric Co., Schenectady, N. Y. Bulletin GEA-881C refers to a 200-amp., 25-volt unit driven by a Model P-20 Continental motor. GEA-1009B describes a larger unit, this being rated at 300 amp., 25 volts, and driven by a Model HS-6 Buda engine. A feature of these sets is a self-adjusting stabilizing reactor for steadying the arc. Another publication just issued by the General Electric Co., designated as GEA-1158A, contains a chart for conveniently determining the cost in cents to operate any appliance for an hour, where the watt rating of the appliance and the net rate of current are known.

NEW CATALOG ON ELECTRIC TOOLS

Electrically operated tools of both the portable and bench types are attractively shown in catalog No. 20, a 40-page booklet issued by The Black & Decker Mfg. Co., Towson, Md. Among the tools described are drills, grinders, hole saws, hammers, sanders, screwdrivers, socket wrenches, nut runners, tappers, saws, valve refacers, and others. Kits containing special tool combinations are listed. Various attachments and accessories also are described. Production is speeded in some operations by mounting the tool on a radial arm or a sliding arm; arms of both types for the mounting of Black & Decker tools are listed and specifications given. Of special interest to aviation mechanics are aircraft-engine valve tools and special aircraft reseating tool sets.

SMALL TRUCK AIDS IN SELLING WELDING EQUIPMENT

It has been the experience of Mr. James Goad, one of the salesmen connected with The Sight Feed Generator Company of West Alexandria, Ohio, that effective sales work can be helped through the use of a well known make of small delivery truck. This truck is loaded with a half dozen or so outfits of equipment which consist of portable acetylene generators, torches, regulators, hose, goggles, etc. Then these are taken around to various prospects and demonstrated right at their places of business. In this way the equipment is made to do its own sales work. The possible buyer sees it in action in his own plant under the conditions in which it would have to be used. If he is interested in it, the generator or equipment is left on trial for several days, and the salesman continues on his way to the next prospect. As the photograph

This Demonstration Truck Was a Factor in Selling 34 Portable Acetylene Generators in a Rural County of 23,500 People.

shows, the truck makes a pleasant appearance and is a traveling advertisement with the name and picture of the equipment on the side.

Mr. Goad has had considerable success with this method of selling, and in one rural county with a population of 23,500 people he has placed 24 portable generators, thus making an average of over one generator to each thousand of population. These generators have been sold to welding shops, machine shops, garages, scrap yards, battery stations, etc.

Mr. C. F. Smith, manager of the above company, states that they have supplied the U. S. Army Air Service with a number of generators for welding repair work on aircraft. He also notes that the company has shipped some fifty of the machines to New Zealand and twenty-five to the Philippine Islands, besides various numbers to Central and South America.

YOUNG ENGINEER EVOLVES GENERALIZED THEORY OF ELECTRICAL MACHINERY

Gabriel Kron, electrical engineer of The Lincoln Electric Co., Cleveland, has derived a simple formula for calculating the performance of any piece of electrical machinery, which it is said will save a great amount of time and labor for designers. The theory underlying this formula was the subject of a paper read by Mr. Kron before the Winter Convention of the American Institute of Electrical Engineers, held in New York City during the last week in January.

Mr. Kron, a Hungarian, arrived in the United States in January, 1921, and entered the University of Michigan, where he received a degree in electrical engineering. He then worked as a draftsman and designer of electrical machinery. Starting in April, 1927, with $200 in his pocket, he made a trip around the world. Back in the United States in October, 1928, he entered the research laboratory of The Lincoln Electric Co., and it has been since that time that he has evolved his generalized theory which has created great interest in the electrical field.

RYERSON ADDS TO DETROIT PLANT

A new heated building with increased facilities for storing and dispatching was recently completed by Joseph T. Ryerson & Son, Inc., at their plant at 1600 E. Euclid Ave., Detroit, Mich. This addition marks the fourth large expansion program of the Ryerson Company during the twelve years of steady growth in Detroit area, and makes this the largest steel-service plant in the area. With a view to future expansion, the Ryerson Company has ground space reserved to give an ultimate 110,000 sq. ft. of added space.

The new building is 120x300 ft., and includes five bays and a large transfer bay at one end with facilities for the inside loading of freight cars. Each bay is served by a crane. Truck loading is facilitated by a driveway through the center of the building.

All kinds of sheets, Allegheny metal, Ascoloy, hot and cold rolled strip steel, bands, and other high-grade steels requiring exceptional care will be stored in this 36,000 sq. ft. of heated warehouse space. An open span, 90x350 ft., between the new

New Addition to Ryerson's Detroit Plant.

unit and the old buildings, is used for storing and dispatching reinforcing bars, some contractors' supplies, and other material not affected by the weather. This area is served by both the Michigan Central and the Grand Trunk Railroads. Twenty-six carloads of steel can now be handled at one time on the Ryerson property.

DEATH OF CHARLES P. BRANT

Charles Pierson Brant, president of the Indiana Oxygen Co., of Indianapolis, Ind., died suddenly at his home on January 30th of a heart attack, at the age of 75. He was best known as a pioneer in the development of the oil industry in this country, and was an authority in this field. He had been a resident of Indianapolis for the past 33 years. Besides his business interests, he was active in Masonic circles. His widow and two sons survive him. Funeral services were held on February 3rd.

NEWS OF THE INDUSTRY

Arthur Mansoff, of the Mansoff Welding Co., Ltd., Brandon, Manitoba, Canada, has made connections with The Bastian-Blessing Co. and The American Brass Co. for handling the sale of "Rego" welding equipment and supplies and of brass rod in Western Canada. Mr. Mansoff sees a large field for the use of welding in the agricultural, oil production and mining industries. While on a recent visit to Chicago, he attended the February meeting of the Chicago Section of the American Welding Society.

Joseph T. Ryerson & Son, Inc., who recently bought the Penn-Jersey Steel Co., has vacated the Camden plant and moved the offices and warehouse stocks to Fifty-Second and Gray Ave., Philadelphia, in the former plant of the Tioga Steel & Iron Co.

The Union Carbide & Carbon Corp. recently bought the sixteen-story office building at 300 Madison Ave., New York City. With this purchase, they now own the entire block on Madison Ave., between Forty-First and Forty-Second Sts.

A. M. Searles has been appointed factory representative and engineer of the Acme Electric Welder Co., of Los Angeles, Calif. Mr. Searles is well known in welding circles in the Middle West as head of the Searles Electric Welding Co., of Chicago.

The J. M. & L. A. Osborn Co., of Detroit, Cleveland, and Buffalo, are acting as factory representatives and distributors in Erie, Lorain, Cuyahoga, Lake and Ashtabula Counties for the line of gas welding and cutting apparatus manufactured by The Harris Calorific Co., of Cleveland.

Fred Clark, formerly welding superintendent for the Smith Bros. Construction Co. in the construction of the 218-mile electric-welded Jal-El Paso pipe line, recently purchased a half-interest in the U. S. Boiler & Welding Co. from Tom Melott and will be the active manager of the business. Mr. Clark is one of the pioneer field welders in the Mid-Continent oil field.

R. V. Alford recently opened the Alco School of Welding at 513 West Main St., Oklahoma City, Okla., to help supply the demand for trained welders occasioned by the big new oil field adjoining the city limits of Oklahoma City. The welding of ferrous and non-ferrous metals is taught. The oxy-acetylene welding course and the arc welding course are $75 each, or $135 if taken together.

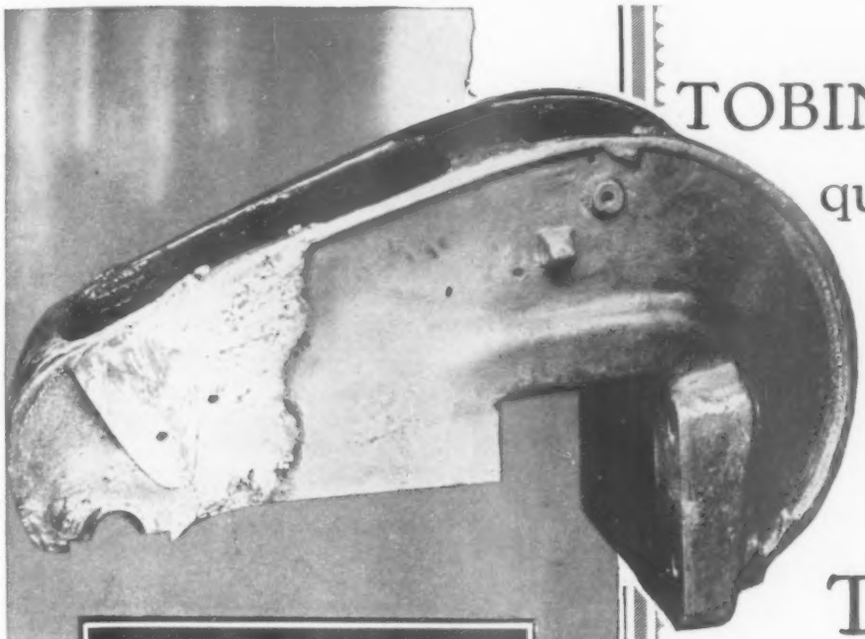
The Western New York Section of the American Welding Society had as their speaker on February 10th, A. M. Candy, general engineer with the Westinghouse Electric & Manufacturing Co., who spoke on "The Application of Arc Welding to Steel Structures and Machinery Design." The program for the remainder of the season is as follows: March 10th, "Pipe Welding in Buildings," by a representative of the Air Reduction Sales Co.; April 17th, annual election of officers, and buffet supper, with a general conference to talk over increased activities of the Section for the coming season; May 26th, lecture on thermit welding with an actual demonstration, by a representative of the Metal & Thermit Corp. All meetings will be held at the Hotel Statler, in Buffalo.

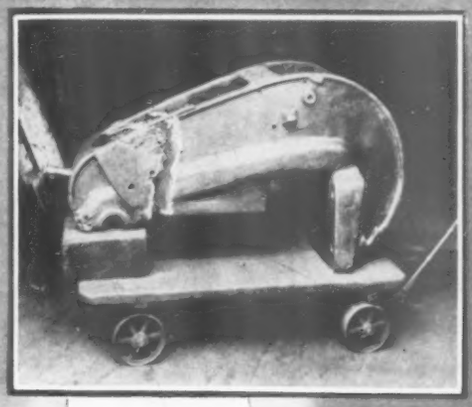
The American Compound Co., of Boston, Mass., has found it necessary to move to larger quarters at 233 Congress St. on account of expanding business. This company, which was formerly located at 383 Atlantic Ave., manufactures fluxes and are distributors of K-G welding and cutting apparatus and supplies.

Wm. J. White has joined the organization of the Torchweld Equipment Co., 224 N. Carpenter St., Chicago, as assistant sales manager. He was previously connected with the Burdett Oxygen Co., the Weldine Corp., and more recently with the A. M. Castle Co.

The Mitchell Co., 326 N. Western Ave., Chicago, is distributing a calendar, size 15½x13½ in., as part of a well-planned campaign to keep the name of the company before its customers. This is one of the oldest-established job welding shops in Chicago.

The Nelson Piping & Equipment Co., 706 Delancey St., Philadelphia, Pa., have been awarded the contract for welding the piping in the new Industrial Building of the Glen Mills School, Glen Mills, Pa.





Iron casting ready for welding with Tobin Bronze. *Above:* 3¼ hours later—the completed job.

TOBIN BRONZE quickly repairs this heavy press frame.. *no pre-heating*

THE cast-iron frame illustrated was fractured in a place which had broken before and had been welded with steel rods. With Tobin Bronze one man repaired the new break in 3¼ hours, using 32½ lbs. of ¼" filler rod, 320 cubic feet of oxygen and 320 cubic feet of acetylene.

In this instance a successful weld was made without pre-heating, whereas to weld a section of this size with cast-iron rods, would have necessitated pre-heating for many hours.

It is often necessary to make a weld where broken parts, by reason of the great size and weight of the casting, are extremely difficult to pre-heat. On work of this kind consider the possibilities of welding with Tobin Bronze. For further information ask for Anaconda Publication B-13.

THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Conn.
Canadian Mill: ANACONDA AMERICAN BRASS LTD.
New Toronto, Ontario

There is a suitable Anaconda Filler Rod for every bronze-welding purpose. Principal Anaconda Welding Rods, with their melting points, are listed below:

for oxy-acetylene welding

Tobin Bronze*	1625°F
Manganese Bronze	1598°F
Brazing Metal	1634°F
Naval Bronze	1625°F
Electrolytic Copper	1981°F
Silicon Copper	1981°F
Phosphor Bronze	1922°F
Everdur*	1866°F

for arc welding

Silicon Copper	1981°F
Phosphor Bronze	1922°F
Everdur*	1866°F

*Reg. U. S. Pat. Off.

ANACONDA
from mine to consumer

ANACONDA
WELDING RODS

J. W. Tatum was recently appointed welding superintendent for the Roger O. Moore Pipe Line Co., Tulsa Trust Bldg., Tulsa, Okla., which concern at present is engaged in laying 50 miles of 4-in. acetylene-welded pipe for the Derby Oil Co. near Newton and Mound Ridge, Kan. Mr. Tatum has had a wide experience as a welding foreman and superintendent with some of the major oil companies. He was the welding superintendent for the Acme Welding & Engineering Co., of Tulsa, which company recently completed the last 54-mile section of the Texas-Empire-Cushing, Okla., to Chicago, electric-welded 12-in. pipe line.

The Cleveland School of Welding, Inc., which is the incorporated name of what was formerly the Cleveland Welding School, had an exhibit of oxy-acetylene welding and cutting equipment as used in the automotive field, at the 1930 Cleveland Automobile Show. Messrs. Randall and Scott had charge of the booth, which attracted great interest.

At a meeting of The Institution of Welding Engineers held at 95 New St., Birmingham, England, January 30th, a paper entitled "Modern Improvements in Electric Resistance Welding Machines" was read by C. A. Hadley, who illustrated his talk with lantern slides.

At the annual meeting of The Kansas Oxy-Acetylene Co., of Wichita, Kan., C. D. Stewart was elected president to take the place of F. D. Stevens, resigned. Mr. Stewart also retains the title of general manager. W. A. Campbell was elected secretary and treasurer, and H. T. Stewart remains as manager. Geo. Austin Brown was appointed as counsel. Messrs. C. D. Stewart, Campbell, and Brown were also elected as directors, the others being H. B. McKibben and J. W. Craig.

The Battle Creek Welding School has been organized in Battle Creek, Mich., to teach courses in light welding, pipe welding, structural welding, aviation welding, electrric welding, commercial acetylene welding, and a complete course in electric and acetylene commercial welding All classes are under the personal direction of A. F. Dillon.

A central heating plant of the Consumers Power Co., Battle Creek, Mich, including an all-welded pipe line from the heating plant through the business section of the city, was recently completed and is now in operation.

The Carter-Miller Mill Furnishing Co., N1324 Ash, Spokane, Wash., has purchased the welding equipment of the former Halidie Machinery Co., and has secured the services of Fred Giesa, who was in charge of the welding department of the Halidie company for the past seven years. Both heavy and light welding will be handled in the new quarters.

New General Electric arc-welding equipment and Lincoln arc-welding machines have been purchased by the Cleveland School of Welding, Inc., Cleveland, Ohio, as a part of their program in meeting the demand for operators.

Charles T. Marsh has been transferred from the Experimental Department of The Taylor-Winfield Corp., at Warren, Ohio, to the sales and service force of that company, and is now located with The Denton & Anderson Co., 808 Peoples Gas Bldg., Chicago, distributors of Taylor-Winfield welders in the Chicago territory. For ten years prior to his joining the Taylor-Winfield organization, Mr. Marsh was engaged in practical welding work and in the development of welding designs and methods in the Highland Park and River Rouge plants of the Ford Motor Co.

The Aero Engineering Service Co., Inc., Wichita, Kansas, who conduct a course in oxy-acetylene welding with particular reference to aircraft welding, have recently moved to 923 N. Main St. K. A. Glatt is in charge of the welding instruction.

Ray Allion, formerly with the Wabash Railroad, was recently added to the personnel of Dillon's Welding Shop, 142 S. Washington Ave., Battle Creek, Mich.

Bids are being asked for a heating system to the new addition of the Liela Montgomery Hospital, in Battle Creek, Mich., which specify welded high-pressure steam lines.

At a recent directors' meeting of the Union Carbide Co. and the Electro Metallurgical Co., both units of Union Carbide & Carbon Corp., Benjamin O'Shea, former president, was elected chairman of the board of each company. Fred H. Haggerson, formerly vice-president of the two companies, was elected to succeed Mr. O'Shea as president. F. P. Gormely was elected vice-president and general manager of both companies.

The Battle Creek, Mich., Flying School is starting a mechanics' course, which includes welding.

Robert E. Kinkead, arc-welding specialist and consulting engineer, formerly located at 3030 Euclid Ave., Cleveland, Ohio, has moved his Cleveland office to the Builders' Exchange building. Mr. Kinkead has also opened a Chicago office at 330 N. Western Ave.

Classified Ads

Help Wanted—75c per line, minimum 4 line
Jobs Wanted—4 lines free.
Other Ads—$1.00 per line, minimum 4 lines.
Counted 8 words to line. Add 6 words for keyed address.

Position Wanted—Man 35 years old with very broad and successful welding experience, both arc and gas, desires position as welder or foreman. He has supervised some large welding jobs, and is used to handling men. Dissolution of a partnership has left him out of work. Address Box 232, care The Welding Engineer.

Salesmen Wanted—Salesmen selling welding apparatus and calling on industrial plants, to handle fabricated steel products. Real proposition available. Address Box 233, care The Welding Engineer.

Distributors Wanted—For the latest welding wire—coated, processed and bare. Write for further information. Welding Wire Co., P. O. Box No. 11, Milwaukee, Wisconsin.

Welding Foremen with good technical knowledge and thorough practical experience in electric welding for permanent position abroad as technical advisers and instructors—one for general electric welding work and one particularly experienced in boilermaking by welded process. State in first letter in detail all past experience, salary received and expected, age and nationality. References required. All applications will be treated strictly confidentially. Address Box 237, care of The Welding Engineer.